SCIENCE

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*LIQUID HYDROGEN.**

FROM the year 1878, when the experiments of Cailletet and Pictet were attracting the attention of the scientific world, it became a common habit in textbooks to speak of all the permanent gases, without any qualification, as having been liquefied, whereas these experimentalists, by the production of an instantaneous mist in a glass tube of small bore, or a transitory liquid jet in a gas expanding under high compression into air, had only adduced evidence that sooner or later the static liquid form of all the known gases would be attained. Neither Pictet nor Cailletet in their experiments ever succeeded in collecting any of the permanent gases in that liquid form for scientific examination. Yet we meet continually in scientific literature with expressions which lead one to believe that they did. For instance, the following extract from the 'Proceedings' of the Royal Society, 1878, illustrates this point very well: "This award (Davy Medal) is made to these distinguished men (Cailletet and Pictet) for having independently and contemporaneously liquefied the whole of the gases hitherto called permanent." Many other quotations of the same kind may be made. As a matter of fact six years elapsed, during which active investigation in this department was being prose-

* Lecture before the Royal Institution of Great Britain.

cuted, before Wroblewski and Olszewski succeeded in obtaining oxygen as a static liquid, and to collect liquid hydrogen, which is a much more difficult problem, has taken just twenty years from the date of the Pictet and Cailletet experiments.

Wroblewski made the first conclusive experiment on the liquefaction of hydrogen in January, 1884. He found that the gas cooled in a capillary glass tube to the boiling point of oxygen, and expanded quickly from 100 to 1 atmosphere, showed the same appearance of sudden ebullition lasting for a fraction of a second, as Cailletet had seen in his early oxygen experiments. No sooner had the announcement been made, than Olszewski confirmed the result by expanding hydrogen from 190 atmospheres, previously cooled to the temperature given by liquid oxygen and nitrogen evaporating under diminished pressure. Olszewski, however, declared in 1884 that he saw colorless drops, and by partial expansion to 40 atmospheres, the liquid hydrogen was seen by him running down the tube. Wroblewski could not confirm Olszewski's results, his hydrogen being always obtained in the form of what he called a 'liquide dynamique,' or the appearance of an instantaneous froth. Olszewski himself seven years later repeated his experiments of 1884 on a larger scale, confirming Wroblewski's results, thereby proving that the so-called liquid hydrogen of the earlier experiments must have been due to some impurity. The following extract from Wroblewski's paper states very clearly the results of his work on Hydrogen:

"L'hydrogène soumis à la pression de 180 atm. jusqu'à 190 atm., refroidi par l'azote bouillant dans la vide (à la température de sa solidification) et détendu brusquement sous la pression atmosphérique présente une mousse bien visible. De la couleur grise de cette mousse, où l'œil ne peut distinguer des gouttelettes incolores, on ne peut pas encore deviner quelle apparence aurait l'hydrogène à l'état de liquide statique et l'on est encore moins autorisé à préciser s'il a ou non une apparence métallique. J'ai pu placer dans cette mousse ma pile thermo-électrique, et j'ai obtenu suivant les pressions employées des températures de —208° jusqu'à —211° C. Je ne peux pas encore dire dans quelle relation se trouvent ces nombres avec la température réelle de la mousse ou avec la température d'ébullition de l'hydrogène sous la pression atmosphérique, puisque je n'ai pas encore la certitude que la faible durée de ce phénomène ait permis à la pile de se refroidir complètement. Néanmoins, je crois aujourd'hui de mon devoir de publier ces résultats, afin de préciser l'état actuel de la question de la liquéfaction de l'hydrogène."*

It is well to note that the lowest thermo-electric temperature recorded by Wroblewski during the adiabatic expansion of the hydrogen (namely, —211°) is really equivalent to a much lower temperature on the gas-thermometer scale. The most probable value is —230°, and this must be regarded as the highest temperature of the liquid state, or the critical point of hydrogen, according to his observations. In a posthumous paper of Wroblewski's on 'The Compression of Hydrogen,' published in 1889, an account appears of further attempts which he had made to liquefy hydrogen. The gas compressed to 110 atmospheres, was cooled by means of liquid nitrogen under exhaustion to —213.8°. By suddenly reducing the pressure, as low a temperature as —223° on his scale was recorded, but without any signs of liquefaction. This expansion gives a theoretical temperature of about 15° absolute in the gas particles. The above methods having failed to produce static hydrogen, Wroblewski suggested that the result might be attained by the use of hydrogen gas as a cooling agent. From this time until his death in the year

* Compt. Rend., 1885, 100, 981.

1888, Wroblewski devoted his time to a laborious research on the isothermals of hydrogen at low temperatures. The data thus arrived at enabled him, by the use of Van der Waal's formulæ, to calculate the critical constants, and also the boiling point of liquid hydrogen.

Olszewski returned to the subject in 1891, repeating and correcting his old experiments of 1884, which Wroblewski had failed to confirm, using now a glass tube 7 mm. in diameter instead of one of 2 mm. as in the early trials. He says: "On repeating my former experiments, I had no hope of obtaining a lower temperature by means of any cooling agent, but I hoped that the expansion of hydrogen would be more efficacious, on account of the larger scale on which the experiments were made." The results of these experiments Olszewski describes as follows: "The phenomenon of hydrogen ebullition, which was then observed, was much more marked and much longer than during my former investigations in the same direction. But even then I could not perceive any meniscus of liquid hydrogen." Further, "*The reason for which it has not hitherto been possible to liquefy hydrogen in a static state, is that there exists no gas having a density between those of hydrogen and of nitrogen, and which might be for instance* 7–10 (H = 1). Such a gas could be liquefied by means of liquid oxygen or air as cooling agent, and be afterwards used as a frigorific menstruum in the liquefaction of hydrogen."

Professor Olszewski, in 1895, determined the temperature reached in the momentary adiabatic expansion of hydrogen at low temperatures, just as Wroblewski had done in 1885, only he employed a platinum-resistance thermometer instead of a thermo-junction. For this purpose he used a small steel bottle of 20 or 30 cc. capacity, containing a platinum-resistance thermometer; in this way the temperatures registered were regarded as those of the critical and boiling points of liquid hydrogen, a substance which could not be seen under the circumstances and was only assumed to exist for a second or two during the expansion of the gaseous hydrogen in the small steel bottle.

The results arrived at by Wroblewski and Olszewski are given in the following table, and it will be shown later on that Wroblewski's constants are nearest the truth.

	Wroblewski, 1885.	Olszewski, 1895.
Critical temperature.....	—240°	—234°
Boiling point.....	—250°	—243°
Critical pressure.....	13 atm.	20 atm.

The accuracy of Wroblewski's deductions regarding the chief constants of liquid hydrogen following from a study of the isothermals of the gas is a signal triumph for the theory of Van der Waals and a monument to the genius of the Cracow physicist. From these results we may safely infer that supposing a gas is hereafter discovered in small quantity four times more volatile than liquid hydrogen, having a boiling point of about 5° absolute, and therefore incapable of direct liquefaction by the use of liquid hydrogen, yet by a study of its isothermals we shall succeed in finding out its most important liquid constants, although the isolation of the real liquid may for the time be impossible.

In a paper published in the *Philosophical Magazine*, September, 1884, 'On the Liquefaction of Oxygen and the Critical Volumes of Fluids,' the suggestion was made that the critical pressure of hydrogen was wrong, and that instead of being 99 atmospheres (as deduced by Sarrau from Amagat's isothermals) the gas had probably an abnormally low value for this constant. This view was substantially confirmed by Wroblewski finding the critical pressure of 13.3 atmospheres, or about one-fourth of that of oxygen. The *Chemical News*, Septem-

ber 7, 1894, contains an account of the stage the author's hydrogen experiments had reached at that date. The object was to collect liquid hydrogen at its boiling point, in an open vacuum vessel, which is a much more difficult problem than seeing it in a glass tube under pressure and at a higher temperature. In order to raise the critical point of hydrogen to about — 210°, from 2 to 5 per cent. of nitrogen or air was mixed with it. *This is simply making an artificial gas containing a large proportion of hydrogen which is capable of liquefaction by the use of liquid air.* The results are summed up in the following extract from the paper: "One thing can, however, be proved by the use of the gaseous mixture of hydrogen and nitrogen, namely that by subjecting it to a high compression at a temperature of — 200° and expanding the resulting liquid into air, a much lower temperature than anything that has been recorded up to the present time can be reached. This is proved by the fact that such a mixed gas gives, under the conditions, a paste or jelly of solid nitrogen, evidently giving off hydrogen, because the gas coming off burns fiercely. Even when hydrogen containing only some 2 to 5 per cent. of air is similarly treated, the result is a white solid matter (solid air) along with a clear liquid of low density, which is so exceedingly volatile that no known device for collecting it has been successful." This was in all probability the first liquid hydrogen obtained, and the method is applicable to other difficultly liquefactible gases.

Continuing the investigations during the winter of 1894, and the greater part of 1895, the author read a paper before the Chemical Society in December of that year entitled, 'The Liquefaction of Air and Research at Low Temperatures,'* in which occasion was taken to describe for the first time the mode of production and use of a Liquid Hydrogen Jet. At the same meeting Professor William Ramsay made an announcement of a sensational character, which amounted to stating that my hydrogen results had been not only anticipated but bettered. The statement made to the Society by Professor Ramsay, reads as follows: "*Professor Olszewski had succeeded in liquefying hydrogen, and from unpublished information received from Cracow, he (Ramsay) was able to state that a fair amount of liquid had been obtained, not as a froth, but in a state of quiet ebullition, by surrounding a tube containing compressed hydrogen by another tube also containing compressed hydrogen at the temperature of oxygen boiling at a very low pressure. On allowing the hydrogen in the middle jacket suddenly to expand, the hydrogen in the innermost tube liquefied, and was seen to have a meniscus. Its critical point and its boiling point, under atmospheric pressure, were determined by means of a resistance thermometer.*" *

This announcement of Professor Ramsay's had from its very specific and detailed experimental character the merit of the appearance of being genuine, although it was never substantiated, either by the production of the Cracow document, or by any subsequent publication of such important results by Professor Olszewski himself. My observation at the time on Professor Ramsay's communication was that quotations had been made in my paper from the most recent publications of Professor Olszewski in which he made *no mention of getting 'Static Hydrogen or of seeing a meniscus' or of getting what Professor Ramsay alleged 'a fair amount of liquid, not as a froth, but in state of quiet ebullition.'* To achieve such a result would require a very different scale of experiment from anything Professor Olszewski had so far described. Naturally an early corroboration of the startling statement

*'Proceedings' of the Chemical Society, No. 158, 1895.

*'Proceedings' of the Chemical Society, No. 195, 1897–1898.

made by Professor Ramsay as to this alleged anticipation was expected, but strange to say Professor Olszewski published no confirmations of the experiments detailed by Professor Ramsay in scientific journals of date immediately preceding my paper or during the following years 1896, 1897 or up to May, 1898. The moment the announcement was made by me to the Royal Society in May, 1898 that, after years of labor, hydrogen had at last been obtained as a static liquid, Professor Ramsay repeated the story to the Royal Society that Olszewski had anticipated my results (basing the assertion solely on the contents of the old letter received some two and a half years before), in spite of the fact that during the interval he, Professor Ramsay, must have known that Professor Olszewski had never corroborated in any publication either the form of the experiments he had so minutely described or the results which were said to follow. Challenged by me at the Royal Society Meeting on May 12, 1898, to produce Olszewski's letter of 1895, he did not do so, but at the next meeting of the Society, Professor Ramsay read a letter he had received during the interval from Professor Olszewski, denying that he had ever stated that he had succeeded in producing static liquid hydrogen. This oral communication of the contents of the new Olszewski letter (of which it is to be regretted there is no record in the published proceedings of the Royal Society) is the only kind of retraction Professor Ramsay has thought fit to make of his published misstatements of facts. No satisfactory explanation has yet been given by Professor Ramsay of his twice repeated categorical statements made before scientific bodies of the results of experiments which, in fact, had never been made by their alleged author. The publicity that has been given to this controversy makes it imperative that the matter should not be passed over, but once for all recorded.

The report of a Friday Evening Discourse on 'New Researches on Liquid Air,'* contains a drawing of the apparatus employed for the production of a jet of hydrogen containing visible liquid. This is reproduced

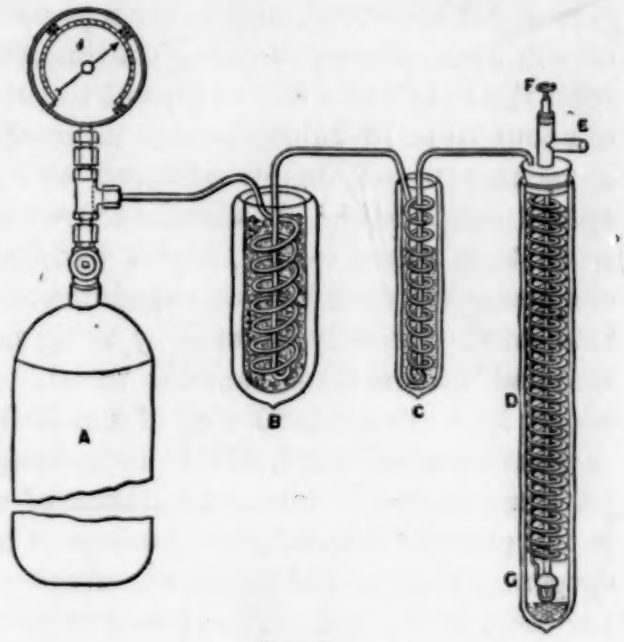

FIG. 1.

in Fig. 1. *A* represents one of the hydrogen cylinders; *B* and *C*, vacuum vessels containing carbolic acid under exhaustion and liquid air respectively; *D* is the coil, *G* the pin-hole nozzle, and *F* the valve. By means of this hydrogen jet, liquid air can be quickly transformed into a hard solid. It was shown that such a jet could be used to cool bodies below the temperature that it is possible to reach by the use of liquid air, but all attempts to collect the liquid hydrogen from the jet in vacuum vessels failed. No other investigator improved on my results,† or has indeed touched the subject during the last three years. The type of apparatus used in these experiments worked well, so it was resolved to construct a much larger liquid-air plant, and to combine with it circuits and arrangements for the liquefaction of hy-

* 'Proceedings' of the Royal Institution, 1896.

† 'Proceedings of the Chemical Society' (No. 158), 1895.

drogen. This apparatus took a year to build, and many months have been occupied in the testing and preliminary trials. The many failures and defects need not be detailed.

On May 10, 1898, starting with hydrogen cooled to —205°, and under a pressure of 180 atmospheres, escaping continuously from the nozzle of a coil of pipe at the rate of about 10 to 15 cubic feet per minute, in a vacuum vessel doubly silvered and of special construction, all surrounded with a space kept below —200°, liquid hydrogen commenced to drop from this vacuum vessel into another doubly isolated by being surrounded with a third vacuum vessel. In about five minutes, 20 c.c. of liquid hydrogen were collected, when the hydrogen jet froze up, from the accumulation of air in the pipes frozen out from the impure hydrogen. The yield of liquid was about one per cent. of the gas. The hydrogen in the liquid condition is clear and colorless, showing no absorption spectrum, and the meniscus is as well defined as in the case of liquid air. The liquid must have a relatively high refractive index and dispersion, and the density appears at first sight to be in excess of the theoretical density, namely 0.18 to 0.12, which we deduce respectively from the atomic volume of organic compounds, and the limiting density found by Amagat for hydrogen gas under infinite compression. A preliminary attempt, however, to weigh a small glass bulb in the liquid made the density only about 0.08, or half the theoretical. My old experiments on the density of hydrogen in palladium gave a value for the combined element of 0.62. Not having arrangements at hand to determine the boiling point other than a thermo-junction which gave entirely fallacious results, experiments were made to prove the excessively low temperature of the boiling fluid. In the first place if a long piece of glass tubing, sealed at one end and open to the air at the other, is cooled by immersing the closed end in the liquid hydrogen, the tube immediately fills where it is cooled with solid air. A small glass tube filled with liquid oxygen when cooled in liquid hydrogen is transformed into a bluish white solid. This is a proof that the boiling point of hydrogen is much lower than any temperature previously reached by the use of liquid nitrogen evaporating *in vacuo*, seeing oxygen always remains liquid under such conditions. A first trial of putting liquid hydrogen under exhaustion gave no appearance of transition into the solid state. When the vacuum tube containing liquid hydrogen is immersed in liquid air so that the external wall of the vacuum vessel is maintained at about —190°, the hydrogen is found to evaporate at a rate not far removed from that of liquid air from a similar vacuum vessel under the ordinary conditions of temperature. This leads me to the conclusion that, with proper isolation, it will be possible to manipulate liquid hydrogen as easily as liquid air.

The boilng point of liquid hydrogen at atmospheric pressure in the first instance was determined by a *platinum-resistance thermometer*. This was constructed of pure metal and had a resistance of 5.3 ohms at 0° C., which fell to about 0.1 ohm when the thermometer was immersed in liquid hydrogen. The reduction of this resistance to normal air thermometer degrees gave the boiling points —238.2° and —238.9° respectively by two extrapolation methods, and —237° by a Dickson formula.* The boiling point of the liquid seems therefore to be —238° C. or 35° absolute, and is thus about 5° higher than that obtained by Olszewski by the adiabatic expansion of the compressed gas, and about 8° higher than that deduced by Wroblewski from Van der Waal's equation. From these results it may be inferred that the critical point of hydrogen is about 50° absolute,

* See *Phil. Mag.*, 45, 525, 1898.

and that the critical pressure will probably not exceed 15 atmospheres.

If we assume the resistance reduced to zero, then the temperature registered by the electric thermometer ought to be —244° C. At the boiling point of hydrogen, registered by the electric-resistance thermometer, if the law correlating resistance and temperature can be pressed to its limits, a lowering of the boiling point of hydrogen by 5° or 6° C., would therefore produce a condition of affairs in which the platinum would have no resistance, or would become a perfect conductor. Now we have every reason to believe that hydrogen, like other liquids, will boil at a lower temperature the lower the pressure under which it is volatilized. The question arises, how much lowering of the temperature can we practically anticipate? For this purpose we have the *boiling point given by the hydrogen gas thermometer*, and critical data available, from which we can calculate an approximate vapor pressure formula, accepting 22° absolute as about the boiling point, 33° absolute as the critical temperature, and 15.4 atmospheres as the critical pressure; then, as a first approximation—

$$\log.\ p = 6.410 - \frac{77.62}{T} \text{mm.} \quad . \quad . \quad . \quad (1)$$

If, instead of using the critical pressure in the calculation, we assume the molecular latent heat of hydrogen to be proportional to the absolute boiling point, then, from a comparison with an expression of the same kind, which gives accurate results for oxygen tensions below one atmosphere, we can derive another expression for hydrogen vapor pressures, which ought to be applicable to boiling points under reduced pressure.

The resulting formula is—

$$\log.\ p = 7.0808 - \frac{88}{T} \text{mm.} \quad . \quad . \quad . \quad (2)$$

Now formula (1) gives a boiling point of 14.2° absolute under a pressure of 25 mm., whereas the second equation (2) gives for the same pressure 15.4° absolute. As the absolute boiling point under atmospheric pressure is about 22°, both expressions lead to the conclusion that ebullition under 25 mm. pressure ought to reduce the boiling point some 7° C. For some time experiments have been in progress with the object of determining the temperature of hydrogen boiling under about 25 mm. pressure, by the use of the platinum thermometer; but the difficulties encountered have been great, and repeated failures very exasperating. The troubles arise from the conduction of heat by the leads; the small latent heat of hydrogen, volume for volume, as compared with liquid air; the inefficiency of heat isolation; and the strain on the thermometer, brought about by solid air freezing on it and distorting the coil of wire. In many experiments, the result has been that all the liquid hydrogen has evaporated

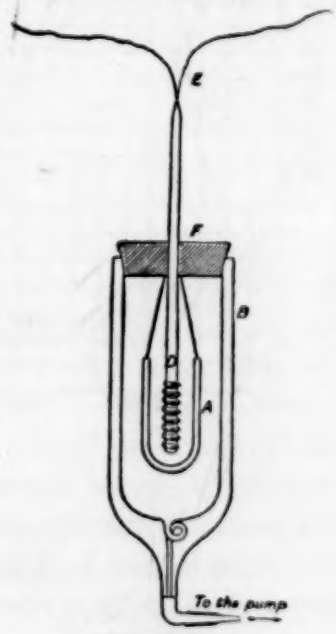

FIG. 2.

before the pressure was reduced to 25 mm., or the thermometer was left imperfectly covered. The apparatus employed will be understood from Fig. 2. The liquid hydrogen collected in the vacuum vessel *A* was suspended in a larger vessel of the same kind, *B*, which is so constructed that a

spiral tube joins the inner and outer test-tubes of which B is made, thereby making an opening into the interior at C. The resistance thermometer D and leads E pass through a rubber cork, F, and the exhaustion takes place through C. In this way the cold vapors are drawn over the outside of the hydrogen vacuum vessel, and this helps to isolate the liquid from the convective currents of gas. To effect proper isolation, the whole apparatus ought to be immersed in liquid air under exhaustion. Arrangements of this kind add to the complication, so in the first instance the liquid was used as described. The liquid hydrogen evaporated quietly and steadily under a diminished pressure of about 25 mm. Naturally the liquid does not last long, so the resistance has to be taken quickly. Just before the reduction of pressure began, the resistance of the thermometer was 0.131 ohm. This result compares favorably with the former observation on the boiling point, which gave a resistance of 0.129 ohm. On reducing the pressure, the resistance diminished to 0.114 ohm, and kept steady for some time. The lowest reading of resistance was 0.112 ohm. This value corresponds to —2.391° C., or only one degree lower on its own scale, than the boiling point at atmospheric pressure, whereas the temperature ought to have been reduced at least 5°, under the assumed exhaustion, according to the gas thermometer scale. The position of the observation on the curve of the relation of temperature and resistance for No. 7 thermometer is shown on the accompanying diagram (Fig. 3). As a matter of fact, however, this platinum thermometer was, when placed in liquid hydrogen, cooled at starting below its own temperature of perfect conductivity, so that no exhaustion was needed to bring it to this point. The question arises then as to what is the explanation of this result? Has the platinum resistance thermometer arrived at a limiting resistance about the boiling point of hydrogen, so that at a lower

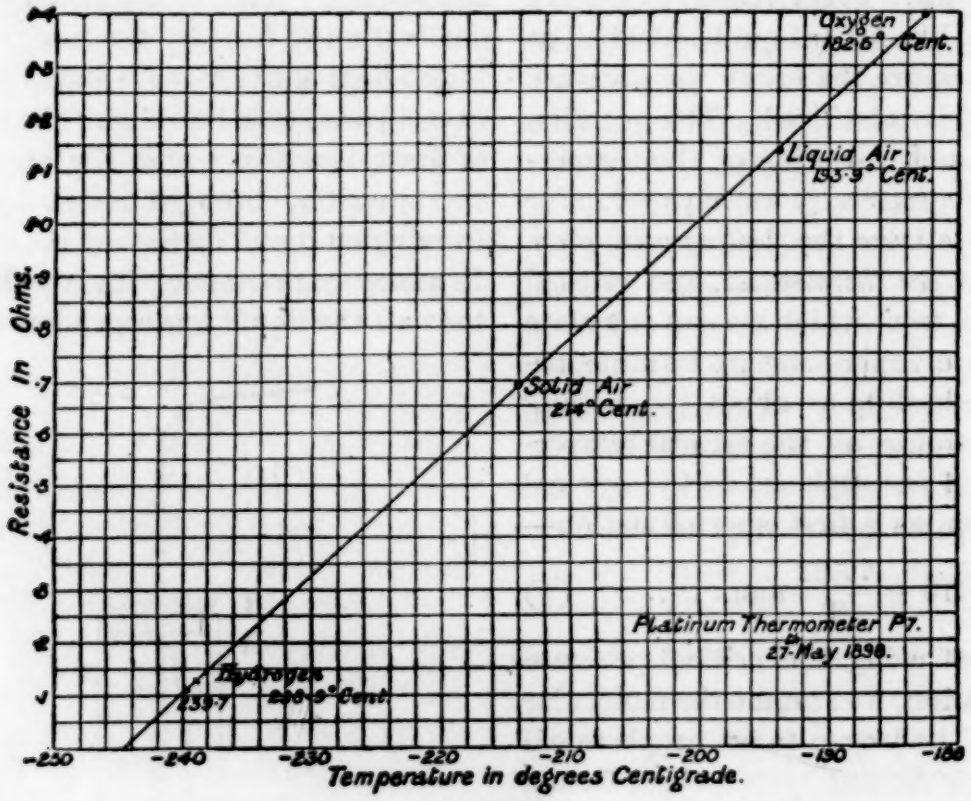

Fig. 3.

temperature its changes in resistance become relatively small—the curve having become practically asymptotic to the axis of temperature? That is the most probable supposition, and it further explains the fact that the temperature of boiling hydrogen obtained by the linear extrapolation of the resistance temperature results in values that are not low enough.

As the molecular latent heats of liquids are proportional to their absolute boiling points, the latent heat of liquid hydrogen will be about two-fifths that of liquid oxygen. It will be shown later, however, that we can reach from 14° to 15° absolute by the evaporation of liquid hydrogen under exhaustion. From analogy, it is probable that the practicable lowering of temperature to be obtained by evaporating liquid hydrogen under pressures of a few mm., cannot amount to more than 10° to 12° C., and it may be said with certainty that, assuming the boiling point 35° absolute to be correct, no means are at present known for approaching nearer than 20° to 25° to the absolute zero of temperature. The true boiling point is in reality about −252° C., in terms *of the gas-thermometer scale*, and the latent heat of the liquid is, therefore, about two-ninths that of an equal volume of oxygen, or one-fourth that of liquid nitrogen. The platinum-resistance thermometer had a zero point of −263.2 platinum degrees, and when immersed in boiling liquid hydrogen, indicated a temperature of −256.8° on the same scale, or 6.4 platinum degrees from the point at which the metal would theoretically become a perfect conductor. The effect of cooling platinum from the boiling point of liquid oxygen to that of liquid hydrogen is to diminish its resistance to one-eleventh.

The difficulties in liquefying hydrogen caused by the presence of air in the gas have been referred to,* and later experiments had for their object the removal of this fruitful source of trouble. This is by no means an easy task, as quantities amounting to only a fraction of one per cent. accumulate in the solid state, and eventually choke the nozzle of the apparatus, necessitating the abandonment of the operation.

Later experiments enabled me to procure a larger supply of liquid hydrogen with which the determination of certain physical constants has been continued. The first observations made with a pure platinum-resistance thermometer had given −238° as the boiling point. A new thermometer, constructed of platinum from a different source, gave practically the same value. As these results might be affected by some constant error, the determination was checked by employing a thermometer constructed from an alloy of rhodium and platinum, containing 10 per cent. of the former. Alloys had been shown by Professor Fleming and the author to differ from pure metals in showing no sign of becoming perfect conductors at the absolute zero of temperature, and a study of the rhodium-platinum alloy had shown that the change in conductivity produced by cooling from 0° to the boiling point of liquid air is regular and may be represented by a straight line. As determined by the rhodium-platinum thermometer, the boiling point of hydrogen was found to be −246° or some 8° lower than the platinum thermometer gave. Two ways of explaining the discrepancy between the two values suggested themselves. Pure platinum, although its resistance may be represented by a straight line almost down to the solidifying point of air, shows signs of a departure from regularity at about this point, and the curve may become asymptotic at lower temperatures. On the other hand, the resistance of the rhodium-platinum alloy diminishes less rapidly at these lower temperatures and is much higher than that of pure platinum under

* 'Proceedings,' 1898, 14, 130.

similar conditions. It follows that its resistance curve, in all probability, deviates less from a straight line than is the case with platinum. Either cause would explain the differences observed, but the lower boiling point (−246° or 27° absolute) seemed to be the more probable as it agreed very fairly with the value for the boiling point calculated by the author from Wroblewski's results. As the use of other pure metals or alloys was not likely to lead to more satisfactory results, the problem had to be attacked in a different way, namely, by means of an 'air' thermometer containing hydrogen under diminished pressure.

A first attempt has been made at determining the boiling-point by a constant-volume hydrogen thermometer, working under diminished pressure. This thermometer, which gave the boiling point of oxygen as 90.5° absolute or −182.5°, gave for hydrogen 21° absolute or −252°. The three determinations that have been made are then as follows: (1) pure platinum resistance thermometer, 35° absolute; (2) rhodium-platinum resistance thermometer 27° absolute; (3) hydrogen thermometer, 21° absolute. From this it appears that the boiling point of hydrogen is really lower than was anticipated, and must range between 20° and 22° absolute. Further experiments will be made with thermometers filled with hydrogen prepared from different sources. A hydrogen thermometer filled with the gas obtained from the evaporation of the liquid hydrogen itself must be employed.

The approximate density of liquid hydrogen at its boiling point was found by measuring the volume of the gas obtained by evaporating 10 cc. of the liquid, and is slightly less than 0.07, or about one-sixth that of liquid marsh-gas, which is the lightest liquid known. It is remarkable that, with so low a density, liquid hydrogen is so easily seen, has so well defined a meniscus, and can be so readily collected and manipulated in vacuum vessels. As hydrogen occluded in palladium has a density of 0.62, it follows that it must be associated with the metal in some other state than that of liquefaction.

The atomic volume of liquid hydrogen at its boiling point is about 14.3, the atomic volumes of liquid oxygen and nitrogen being 13.7 and 16.6 respectively at their boiling points. The weight of a litre of hydrogen gas at the boiling point of the liquid is about the same as that of air, at the ordinary temperature. The ratio of the density of the hydrogen gas at the boiling point to that of the liquid is approximately 1:60, as compared with a ratio of 1:255 in the case of oxygen under similar conditions.

The specific heat of hydrogen in the gaseous state and in hydrogenized palladium is 3.4, but may very probably be 6.4 in the liquid substance. Such a liquid would be unique in its properties; but as the volume of one gramme of liquid hydrogen is about 14–15 c.c., the specific heat per unit volume must be nearly 0.5, which is about that of liquid air. It is highly probable, therefore, that the remarkable properties of liquid hydrogen predicted by theory will prove to be less astonishing when they are compared with those of liquid air, volume for volume, at corresponding temperatures.

With hydrogen as a cooling agent we shall get to from 13° to 15° of the zero of absolute temperature, and its use will open up an entirely new field of scientific inquiry. Even so great a man as James Clerk Maxwell had doubts as to the possibility of ever liquefying hydrogen.* He says: "Similar phenomena occur in all the liquefiable gases. In other gases we are able to trace the existence of attractive force at ordinary pressures, though the compression has not yet been carried so far as to show any repulsive force. In hydrogen the repulsive force seems to prevail even at ordinary

*See Scientific Papers, 2, 412.

pressures. This gas has never been liquefied, and it is probable that it never will be liquefied, as the attractive force is so weak." In concluding his lectures on the non-metallic elements delivered at the Royal Institution in 1852, and published the following year, Faraday said:* "There is reason to believe we should derive much information as to the intimate nature of these non-metallic elements, if we could succeed in obtaining hydrogen and nitrogen in the liquid and solid form. Many gases have been liquefied: the carbonic acid gas has been solidified, but hydrogen and nitrogen have resisted all our efforts of the kind. Hydrogen in many of its relations acts as though it were a metal; could it be obtained in a liquid or a solid condition, the doubt might be settled. This great problem, however, has yet to be solved, nor should we look with hopelessness on this solution when we reflect with wonder—and as I do almost with fear and trembling—on the powers of investigating the hidden qualities of these elements—of questioning them, making them disclose their secrets and tell their tales—given by the Almighty to man."

Faraday's expressed faith in the potentialities of experimental inquiry in 1852 has been justified forty-six years afterwards by the production of liquid hydrogen in the very laboratory in which all his epoch-making researches were executed. The 'doubt' has now been settled; hydrogen does not possess in the liquid state the characteristics of a metal. No one can predict the properties of matter near the zero of temperature. Faraday liquefied chlorine in the year 1823. Sixty years afterwards Wroblewski and Olszewski produced liquid air, and now, after a fifteen years' interval, the last of the old permanent gases, hydrogen, appears as a static liquid. Considering that the step from the liquefaction of air to that of hydrogen is relatively as great in the thermodynamic sense as that from liquid chlorine to liquid air, the fact that the former result has been achieved in one-fourth the time needed to accomplish the latter proves the greatly accelerated pace of scientific progress in our time.

The efficient cultivation of this field of research depends on combination and assistance of an exceptional kind; but in the first instance money must be available, and the members of the Royal Institution deserve my especial gratitude for their handsome donations to the conduct of this research. Unfortunately its prosecution will demand a further large expenditure. It is my duty to acknowledge that at an early stage of the inquiry the Hon. Company of Goldsmiths helped low temperature investigation by a generous donation to the Research Fund.

During the whole course of the low-temperature work, carried out at the Royal Institution, the invaluable aid of Mr. Robert Lennox has been at my disposal, and it is not too much to say that, but for his engineering skill, manipulative ability and loyal perseverance, the present successful issue might have been indefinitely delayed. My thanks are also due to Mr. J. W. Heath for valuable assistance in the conduct of the experiments.

JAMES DEWAR.

* See Faraday's Lectures on the Non-Metallic Elements, pp. 292–3.

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*SOME RECENT CONTRIBUTIONS TO TERRESTRIAL MAGNETISM.**

DURING the past five years a most remarkable interest in magnetic work has been shown throughout the civilized world. The present time can well be likened to the years when Gauss inaugurated a Magnetic Association, consisting of investigators from all countries, in order to carry out observa-

* A paper read before the Philosophical Society of Washington, March 17, 1900.

tions simultaneously at stated periods, for the purpose of deducing laws governing the complex phenomena of the earth's magnetism, and to recognize harmony in irregularities apparently subject to no law.

Almost every civilized country has either just completed a magnetic survey, or is taking the necessary steps for the inauguration of such work on a grander and more comprehensive scale than ever before. The writer remarked this especially during his recent visit at foreign observatories, undertaken for the purpose of comparing a set of the U. S. Coast and Geodetic Survey instruments with the Observatory Standards. A veritable boom in magnetic work seems to have set in. Thus Eschenhagen, in charge of the magnetic work of the Prussian Meteorological Institute is conducting a magnetic survey of Prussia. Captain Denholm Fraser, of the Royal Engineers of England, is at present actively engaged in making the necessary arrangements for inaugurating a detailed magnetic survey of India and Burma. Captain Lyons, of the Royal Engineers, in charge of the Geological survey of Egypt, who has for some years been making magnetic observations during his journeys in various parts of Egypt, is now planning to make a systematic survey of that country.

The Australasian Association for the Advancement of Science at its Sidney meeting in 1898, on the recommendation of Section A, created a committee for the purpose of promoting the study of Terrestrial Magnetism in the Australasian colonies, and passed a resolution ordering the New Zealand Government, in particular, to establish a permanent magnetic observatory in that colony, and subsequently to initiate a general magnetic survey. The Secretary of the Committee, Mr. C. Coleridge Farr, was very energetic and persistent in arousing the New Zealand people to take an interest in the matter, and the consequence was that the New Zealand Government passed a vote of 500 pounds sterling towards the establishment of a permanent station. Mr. Farr is at present making the preliminary arrangements for the establishment of a magnetic observatory and for the inauguration of a magnetic survey.

As another result of the 1898 meeting of the Australasian Association, the Melbourne Observatory has been granted funds for reducing the magnetic records of the past thirty years. It is extremely fortunate for the advancement of science of Terrestrial Magnetism in this part of the globe that such an energetic and enthusiastic investigator as P. Baracchi is at the head of the Melbourne Observatory.

There have been recently established new magnetic observatories at the following points: Munich, Germany; Genoa, Italy; Mexico City, Mexico. The important advance that this country has made towards setting on foot a detailed magnetic survey of our dominions and for the erection of the necessary observatories has already been described.

With these few prefatory remarks, I will now briefly mention a few of the important recent contributions to our knowledge of Terrestrial Magnetism.

The theoretical investigations of Dr. Adolf Schmidt of, Gotha, Germany.—Dr. Schmidt has just completed an elaborate harmonic analysis of the earth's permanent magnetic field. His investigations are, in a certain sense, an amplification and an extension of Gauss's great work entitled 'The General Theory of the Earth's Magnetism.' Many investigators fail to see that Gauss's investigations elaborated any *theory* of the earth's magnetism and the question, "What is Gauss's theory of the earth's magnetism?" may, therefore, deservedly occupy our attention for a few minutes. Were I asked this question, I would reply as the lamented Herz did in his book

on 'Electric Waves,' to the question "What is Maxwell's electro-magnetic theory of light?" Herz's reply was, "Maxwell's theory is that which is contained in his equations defining the electro-magnetic field," and so might I reply if I were hard pressed, that "Gauss's theory is that which is contained in his equations consisting of spherical harmonic terms defining the earth's permanent magnetic field." But what do his equations imply? His equations involve the following theoretical assumptions: That all of the earth's permanent magnetic field is due to causes residing within the earth's crust which are of a character that can be referred to a potential, so that, knowing the value of the potential, all the component parts, namely, that directed north and south along the meridan, that directed east and west along a parallel of latitude, and that directed vertically downward can be readily computed. If now, these theoretical equations, when applied to the actual observations of the earth's magnetic force in various parts of the globe, are satisfied within the errors of observation, then the assumptions underlying the equations have been proved, and that is what Gauss did, and therein, I should say, consists his theory. The equations then represent a definite physical fact.

Now, Dr. Schmidt, in view of the fact that, since the days of Gauss, observations have been greatly multiplied, decided to test the Gaussian hypothesis anew, and so in his analysis he does not begin by assuming the existence of an inner potential function governing the entire magnetic force, but, instead, makes a separate adjustment of each of the three rectangular components and so obtains *three* spherical harmonic expressions instead of *one* as Gauss did. He carries his expressions to terms of the sixth order, Gauss stopping at the fourth. The agreement or disagreement in the coefficients of the harmonic terms in the three separate expressions would test the Gaussian hypothesis, and Schmidt obtains the following conclusions:

The earth's magnetic force consists of three parts:

1. *The greatest part.*—This is to be referred to causes within the earth's crust and possesses a potential.

2. *The smallest part about $\frac{1}{10}$ of the entire force.*—This is due to causes outside the earth's crust and likewise possesses a potential.

3. *A somewhat larger part than the preceding.*—This does not possess a potential, and, in consequence, points to the existence of vertical earth air electrical currents. The currents amount, on the average, for the entire earth's surface, to $\frac{1}{6}$ of an ampere per square millimeter.

Parenthetically, I may remark that Dr. Schmidt is somewhat skeptical about the proof of the existence of the third portion, believing that errors of observation may have produced such a result. I simply wish to emphasize that, in the main, Gauss's theory (and I may now use this expression—having explained what I mean) has been verified.

This indefatigable worker, Dr. Schmidt, has, within a few months, made another notable contribution, namely, on the 'Cause of Magnetic Storms.'

If we compare the photographic traces, obtained at magnetic observatories, showing the variation in magnetic declination or in horizontal intensity during a magnetic storm at two neighboring points, a striking agreement at once appears to the eye. Examine these curves closer and you will find that the agreement consists principally in the number and position of the individual waves or peaks composing the curves, whereas the magnitudes of the corresponding peaks or hollows show distinct differences, so that at times a peak of one curve

appears greatly flattened out in the other one, and hence a maximum in one may correspond to a minimum in the other. The farther the stations are from each other, the more frequent and clearer become the differences between the curves, so that at very distant points there are but few details which the curves have in common. Especially characteristic of these fluctuations of the earth's magnetism is the continual change controlling them; remarkable similarity is followed in a few minutes by a pronounced dissimilarity—a violent outbreak in the one curve corresponds to an almost imperceptible bending of the curve in the other. This well known peculiarity in magnetic storms shows without doubt that local influences are the prime cause of the phenomena—occurrences of rapidly changing strength and extent which —now here—now there—make their presence strongly felt, and while the effect may reach practically simultaneously over a very extensive area, the maximum travels rapidly from place to place. Dr. Schmidt made a mathematical analysis of various magnetic storms and in particular of the one which occurred on February 28, 1896, and whose course was followed one hour, from 6 to 7 p. m. Greenwich time, at the suggestion of Professor Eschenhagen, simultaneously by 15 observatories distributed over the earth. His investigations clearly showed that the disturbance vectors at times converged to a point, at other times radiated from a point and, in times of magnetic calms (comparatively speaking), the vectors at the various stations were almost parallel to each other as though pointing to a distant force-center. Furthermore that the points of convergence, in general, moved progressively forward with a velocity of about one kilometer in a second and also that they were at times nearly stationary. In view of the fact that the cause of the diurnal variation of the earth's magnetism must apparently be referred to electric currents in the upper regions of the atmosphere, Dr. Schmidt believes that the immediate cause of the magnetic storms is to be referred to electric whirls or vortices which separate themselves from the general electric field in the atmosphere just as do the cyclones and anti-cyclones known to the meteorologists. Taking also into consideration the vertical disturbing components and applying Ampere's rule to the current systems revealed by the disturbing forces, it follows that, for the greater part, the causes of our observed magnetic storms come from outside of the earth's crust.

Professor Eschenhagen's recent work follows naturally upon this brief statement of the work of Dr. Schmidt, for it is largely due to his energy and the instrumental methods he has devised that Dr. Schmidt's investigations have been made possible.

We shall have thrown, presently, upon the screen a lantern slide showing the delicate transportable variation instruments devised by Eschenhagen. The results reached by him with these instruments revealed the desirability of again inaugurating a system of simultaneous observations of the earth's magnetic variations at various points, and so was begun the scheme of observation which furnished Dr. Schmidt with the necessary material. Eschenhagen has likewise made some very interesting investigations as to the effect of Berlin electric tramways at various distances, with the aid of his simple set of variation instruments.

You will see later on the screen curves obtained by these instruments showing the effect of the tramways at various distances. If these small variation instruments prove upon trial, covering a sufficiently long period, to be satisfactory in every respect, their small initial cost and also that of their maintenance will, without doubt, do much towards increasing the number of stations

recording the variations of the earth's magnetism, and so we may hope some day to get the material that is needed for a satisfactory study of these phenomena.

Dr. W. van Bemmelen, who has succeeded Professor van der Stok as Director of the Batavian Magnetic Observatory, has recently issued a new set of isogonic charts for the epochs 1500, 1550, 1600, 1650 and 1700. Magneticians owe a great debt of gratitude to this enthusiastic and painstaking investigator for the exhaustive search he has made for old magnetic data in the various European libraries. Only one who is engaged in similar work can appreciate the amount of love and perseverance necessary for such work. It is also exceedingly gratifying and commendable that the author gives in his publication the data upon which the charts are based.*

L. A. BAUER.

U. S. COAST AND GEODETIC SURVEY.

EXOTIC MOLLUSCA IN CALIFORNIA.

THE number of foreign molluscan species in California has notably increased in the past few years, and includes both terrestrial and marine forms, detected by various collectors in and around San Francisco bay.

With the single exception mentioned below, the introduction of these exotic forms has been purely accidental, simple incidents in the usual course of business traffic or commercial interchange.

First, among the land shells we find the well known snail *Helix aspersa*, a common European species, largely used for food on the continent and familiar to persons who have patronized the restaurants of Paris. This species was intentionally introduced or 'planted,' in California over forty years ago by Mr. A. Delmas, of San José, Santa Clara county, who brought the stock from France and turned it out among the vineyards on the west bank of the Guadalupe, a small river that flows northerly through Santa Clara Valley and empties into the southerly end of San Francisco bay near Alviso. The soil where the snails were placed is a rich sandy loam and the place well shaded. When the summer heats reach the maximum, the *Helices* descend into the ground several feet, hiding in the cracks that form, as the ground dries, and the gopher-holes also furnish cool retreats and protection. The region above named is one of exceeding fertility. It was settled by a few French families. The introduction of *H. aspersa* by Mr. Delmas was made for edible purposes, or in common parlance 'with an eye to the pot.' Mrs. Bush, of the Normal School in San José, informs me that the snails have thriven, and have extended their territory from the starting point on the west bank of the stream to the easterly side, and have multiplied to such an extent, that in some instances they are troublesome in the gardens. Mr. Delmas, the elder, also planted *H. aspersa*, in San Francisco and Los Angeles. I have never met with it in my collecting rambles in San Francisco or the outskirts of that city, nor heard of its having been detected by any collector. This particular plant was probably a failure, for a more unfavorable region than that of San Francisco forty years ago, with its cold sea winds, fog, sand-dunes and shifting sands and sparse ligneous scrubby vegetation it would be hard to find. At the present day the chances for success are altogether better, for the greater area of the city is covered by residences, with plats of grass, garden patches and flower-beds which are frequently watered and the general conditions are more promising. It would doubtless

*In connection with above paper there were exhibited 30 lantern slides, consisting of portraits of prominent magneticians, views of magnetic observatory buildings and instruments, and of photographic traces derived from magnetographs.

find a congenial environment in Golden Gate Park; its occurrence there is only a matter of time. I have learned recently that some party in the westerly section of the city propagates or did propagate *H. aspersa*. Mr. Fred L. Button, of Oakland, has informed me that it occurs* in many of the gardens and private grounds in that place, and that one of his neighbors employed a man half a day 'cleaning them out of his garden.' Professor Keep, of the Mills College, last summer collected 'a fine living specimen' at Pacific Grove, Monterey, which is more than fifty miles south of the original Delmas plant on the Guadalupe.

It is now common in East Side Park and is also reported as occurring in Elysian Park in Los Angeles. These are, no doubt, the descendants of the stock planted by Delmas so many years ago.†

Mr. W. G. Binney, in his 'Terrestrial Air-breathing Mollusks of North America etc.' (Vol. V., July, 1878), reports *H. aspersa*, as found "In gardens in Charleston, S. C., and vicinity, where it has existed for fifty years; * * * it has also been found at New Orleans and Baton Rouge; Portland, Maine; Nova Scotia; Santa Barbara, Cal.; Hayti; Santiago, Chili; etc.;" and Mr. Binney, if I am not mistaken, has raised them in his grounds at Burlington, N. J. As he says, "it evidently is a species peculiarly adapted to colonization."

I have always doubted its occurrence at Santa Barbara; it has never been confirmed by any collector to my knowledge. It was, in the first instance, credited to this place on the testimony of a communication to the Zoological Society of London, by Professor Edward Forbes, in which were described the shells collected in the course of surveying voyages of Captain Kellett and Lieutenant Wood of the Royal Navy, in the ships *Herald* and *Pandora*. The locality marks and labels were, unfortunately, badly mixed, and confusion was the inevitable result—Lower California species were credited to the far north, and so on.

A recent careful inquiry made for me by a friend utterly failed to obtain any data, showing its existence at Santa Barbara* or thereabout at any time.

From the foregoing it will be seen that this species is fully established on both coasts of the United States and it is likely to extend its territorial domain in harmony with the prevailing spirit of the times.

Living *Helix pomatia*, a larger species, also European, has been imported by a leading grocery firm in San Francisco to supply its patrons. This is the snail *par excellence* of Continental epicures and was propagated on an extensive scale in the palmy days of ancient Rome as a dainty for the patrician palate on festal occasions; it is not unlikely that sooner or later this species also will be found in some congenial spot outside of the grocery store and in course of time become an inhabitant of California.

More than fifteen years ago a species of slug, *Amalia Hewstoni*, made its appearance in the grass plots of San Francisco; it was described by Dr. J. G. Cooper. It soon became a nuisance; even a regularly ordained clergyman spoke of it as 'a slimy brute'; however this may be, it has now 'expanded' its territory so as to include Seattle in the north and San Diego in the south. Dr. Pilsbry says it may be identical with the

My esteemed friend, the late Dr. Newcomb, who lived in Oakland many years, may have planted some in his garden as an experiment. He had at one time on his grounds several living California forms of different species.

† I have been told that the employees in the park are of the opinion that it was incidentally introduced with foreign plants. They are not aware of the Delmas fact. Its presence in the park may, perhaps, be due to both.

* Vide my paper 'On *Helix aspersa* in California,' in Annals of New York Acad. Sciences, May, 1881, pp. 129–139.

European *A. gagates*; it is not a native Californian. In addition to examples of *Helix aspersa* I have recently received specimens of *Zonites* (*Vitrea*) *cellaria* Müll. and *Zonites* (*Vitrea*) *draparnaldi* Beck, and the little bulimoid, *B. ventrosus* Fer, all from the lawns and flower-beds of Oakland, collected by Henry Hemphill..

Of the above, *Z. cellaria* has an almost world-wide distribution through the instrumentality of commerce. On the Atlantic side from Quebec to Charleston, S. C., along the coast, inland (in greenhouses) at Alleghany City, Pa., and Detroit, Mich. *Z. draparnaldi* is found in the greenhouses of Seattle according to Dr. Pilsbry and has before been reported as occurring in Oakland. The little bulimoid form detected by Mr. Hemphill has not, to my knowledge, been previously found anywhere in North America. It is a continental species. I do not find in the books, any intimation of its occurrence in the British Isles though its absence from territory so comparatively near is remarkable. It has been reported from Bermuda. The occurrence of these European forms of *Zonites* and *Bulimus* in the gardens of Oakland are quite likely due to plant importations. A single example of the little *Helicodiscus lineatus* Say, was noticed by me several years ago, as having been collected in Oakland by Mr. Hemphill. Binney* says of this peculiar form, that it "inhabits all of the Eastern, Central and Pacific Provinces, having been found from Gaspé to Texas; on the Rio Chama, New Mexico; in Idaho; in Oakland, Cal." This is misleading, as it has not been detected anywhere within the Pacific province as defined by him outside of Oakland, and only here in the single instance above mentioned. Mr. Hemphill has also collected *Cochlicopa lubrica* Müll. (= *Ferrussacia subcylindrica* L.) on Grizzly Peak back of the university grounds at Berkeley. This form has heretofore been reported from Oregon and Alaska, and presumably belongs to the circumboreal fauna.

* Manual of American Land Shells, Bull. U. S. N. Mus. No. 28, 1885, p. 75.

MARINE SPECIES.

Having completed our review of the terrestrial species, we may now consider the marine forms, which are confined almost exclusively to San Francisco bay.

The presence of the Virginia oyster in this region is wholly due to business enterprise; its introduction dates from about the time of the completion of the overland railways. Upon the completion and operation of the transcontinental lines certain of the San Francisco oyster dealers commenced the importation by the carload of small or seed oysters, one and two years old, from the Atlantic side, for planting in San Francisco bay, where after a couple of years they attain a marketable size. These importations of *Ostrea Virginica* have been continued ever since, as this species, owing to some unfavorable peculiarities in the new environment, does not increase sufficiently to meet the demands of trade.

The importations of the seed oysters for the nine years, ending with 1895,* amounted to 15,271,000 pounds, costing $350,000.

As an incident of these importations we find several familiar species have been unintentionally introduced, some of which have already established themselves, and appear to be permanently naturalized, as well as others that are gaining a foothold.

The most important of these accidental introductions is the common sand-clam, *Mya arenaria* of the Atlantic Seaboard, variously known as the 'soft-shelled,' 'squirt,' 'long-necked,' clam, and 'mananose.'

There probably has never been in the history of commerce an instance of an accidentally introduced animal species that has proved so economically valuable as this.

* Report of U. S. Fish Com. for 1896.

It was first detected on the eastern shore of the bay, in November, 1874, by Mr. Hemphill, and was soon after described from his specimens, which were about two-thirds the average adult size, by the late Dr. Wesley Newcomb, as *Mya Hemphillii*. It has multiplied wonderfully and is found everywhere in the Bay region, and has apparently crowded out certain indigenous forms like *Macoma nasuta*, before the advent of *Mya*, one of the commoner clams; it is now comparatively scarce. While the shells of *Macoma* are abundant in the kitchen-middens and aboriginal shell-heaps and mounds that are so numerous on the adjacent shores, not a sign of *Mya* has been detected. There is not the slightest doubt of the introduction of the latter form in the way indicated.

Some fifteen or twenty years ago, it happened that I was an invited guest at a clam-bake on the Sausalito shore, and made the acquaintance of the presiding genius of the culinary department, himself an interesting specimen, a cross between fisherman, clam-digger, cook and sea-dog, a sort of 'alongshore jack-at-all-trades.' We had a prolonged confab about clams and clam-bakes. The discussion closed with the remark by him, "what a heap o' shekels I could have made in early days, if these squirt-clams had been in the bay."

Notwithstanding the great increase in the population of San Francisco, Oakland and other cities and towns in this general region and the consequent increased demand, the clam-beds exhibit no hints of depletion. They furnish an abundant supply of wholesome and nutritious food, and that, too, at an exceedingly low price, for the solid meats are retailed in the markets at fifty cents per gallon.

Plantings of *Mya* have been made at Santa Cruz and perhaps elsewhere in the south, and in Shoalwater bay in the north. The latter by Captain Simpson, of San Francisco, many years ago, who informed me that his experiment was a success and had resulted in an ample harvest. It has also been planted elsewhere on the coast of Washington and in Coos Bay near Marshfield, Oregon.

The fusiform species, *Urosalpinx cinereus* Say, the oyster-drill of the Atlantic coast, was discovered on the oyster beds near Belmont on the westerly shore of the San Francisco bay as long ago as 1889, by Mr. C. H. Townsend, of the United States Fish Commission. It was detected last year by Mr. E. E. Smith, of Stanford University, near Redwood City, on the same side of the bay, to the south of Belmont.

Mr. Hemphill collected it in 1898 on the old oyster beds on the Alameda flats of the Eastern Shore, a dozen or more miles from the other localities. At the last named place Mr. Hemphill has recently detected the 'slipper shell,' *Crepidula convexa* Say var. *glauca* Say. The familiar form, *Modiola plicatula* Lam., was found, living, at a point three miles north of Stanford University, in 1894, by Mr. N. F. Drake. This species which ranges on the Atlantic side, from Nova Scotia to Georgia, was particularly abundant fifty years ago in that part of the city of Boston known as the Back-bay district, now traversed by beautiful streets and avenues and exhibiting many fine examples of architecture. By the filling in of this extensive area several hundred acres of wet and dry marsh-land and mud-flats, countless thousands of this *Modiola* were buried alive. It remains to be seen, whether at any point on the Pacific Coast, this form will become approximately as abundant.

It will be noticed from the foregoing that twelve exotic species of Mollusks occur or have been detected in California.

1. *Helix aspersa* Müll.
2. *Amalia Hewstoni* Cp.
   (= *A. gagates*).
3. *Zonites* (*Vitrea*) *cellaria* Müll.
4. *Zonites* (*Vitrea*) *Draparnaldi* Beck.

5. *Bulimus* (——) *ventrosus* Fer.
6. *Helicodiscus lineatus* Say.
7. *Cochlicopa lubrica* Müll.
(= *Ferrussaccia subcylindrica* Linn.)

of Europe, and

8. *Ostrea Virginica* Gmelin.
9. *Mya arenaria* Linn.
10. *Modiola plicatula* Lam.
11. *Urosalpinx cinereus* Say.
12. *Crepidula convexa* var. *glauca* Say.

of the Atlantic seaboard.

With the exception of numbers 2 and 7 examples of the foregoing have been placed in the National Museum.

ROBERT E. C. STEARNS.

LOS ANGELES, CAL.

SCIENTIFIC BOOKS.

MANUAL AND MECHANICAL PRODUCTIVITY.*

THE report of the United States Commissioner of Labor, Mr. Carroll D. Wright, recently issued, on 'Hand and Machine Labor,'* like all our reports from that source, is rich in facts and data. This report has, naturally, in consequence of its intrinsic importance, as well its admirable form and wealth of information, attracted much attention. Mr. Wright has himself given a resumé of the work in the March issue of *Gunton's Magazine;* London *Engineering* and the *Scientific American* devote space to a summary and we now find in the February number of the *Bulletin de la Société d'Encouragement, pour l'Industrie nationale*, an elaborate article by the distinguished French writer, M. E. Levasseur, in which the abstract of Mr. Wright's report constitutes the *pièce de résistance.* The facts illustrated in this remarkable document are, in substance, the following:

The comparison made is, in general, with the methods of the earlier times, antedating the present system of machine-production in which the hands and even the brains of the workmen are reinforced and made enormously more productive by the employment of machinery of great power, activity, accuracy and endurance. It is the comparison of the work and productivity of the days of unaided manual labor of the last century with the production of our own time of labor-aiding machinery and of industrial organization. The real progress described, surprising as it may seem, has actually taken place mainly in the last half century, and in large proportion since about 1870, the date of initiative assumed in Mr. Wells' famous 'Recent Economic Changes.' Within this period, the changes have been studied in eighty-eight principal industries and about seven hundred subsidiary lines. All the data are tabulated in convenient form and the presentation thus made is most admirably adapted for the purposes of the economist, the engineer and the manufacturer interested in the principles of economics controlling his art.

The general deductions are that, while the number of operations in the production of each article has usually considerably increased, and while the machine with its attendant turns out enormously larger product than the unaided workman, the time required for the production of a given amount of product has quite as extraordinarily decreased; the costs of product have proportionally decreased; the market has been enormously expanded and, unexpected but true, the number of workmen has very greatly increased in each industry thus aided and their wages have followed the upward trend of production. Thus, lower prices of product, and larger production with rising wages for more workmen employed, have been consequent upon the work of the inventor and the genius of the 'entrepreneur,' as the economists, curiously, often denominate the manufacturer and the organizer of industries. Invention has immensely augmented, rather than displaced, labor in every manufacturing industry; not even excepting agriculture, where the inventor has supplied the mower and the reaper, the seeder and threshing machine to increase the effectiveness of the manual worker ten times over.

M. Levasseur, in his extended study of such comparisons of the work of the unaided hand with the work of that machine-assisted, traces the history of the introduction of inventions and machinery, with the gradual rise and more gradual fall of the ignorant prejudice of

*Thirteenth Annual Report; Washington Gov't Print. 1899. 2 Vols. Pp. 1597.

the people most advantaged by improvements made by the inventor, and shows, ultimately, that what he calls the 'Economic Paradox' finds place in all machine-reinforced industries. This principle is: the costs being given in detail, it will be found that, with stated costs, there is a certain production which will give the largest dividends. There is a 'golden mean,' as the writer has been accustomed to call it, when developing a similar principle in the production of power from the heat-engines, departing from which, in any direction, efficiency will be sacrificed and the returns on the investment reduced. This is probably true of any one element of production, varying alone. This economic law is well illustrated in the preceding case by the reversal of the 'law of supply and demand,' as usually stated without qualification, by the progress of invention and organization; giving increased employment by giving one man the power to do the work of many, by raising wages while increasing production and giving enlarged profits while reducing prices; extending markets faster than increased production by labor-assisting machinery can supply them and affording employment to increasing numbers of workmen; elevating them from the lower to the higher strata, while giving work of any stated amount, in product, to a fraction of the number of men formerly required.* The cost of plows, for example, as given by Mr. Wright in his report, has fallen from $54 to $8 and less, each; while the time demanded for production per unit, is reduced from 1180 hours to less than 40. Meantime wages have doubled and quadrupled, and, even at the higher price, labor is eight times as effective as formerly. The user of the plow reduces cost of labor, per acre of ground cultivated, from $3.55 to $0.66 reinforcing his own strength by the machine in nearly every operation, from seedtime to harvest.

The agriculturist, with the aid of machinery, supplies butter of a perfectly uniform and better quality, as an average, by the use of machinery, reducing costs, per 500 pounds, from $10.66 to $1.78. The number of butter-makers has been enormously increased in this period, while the product is made in one-tenth the time and at one-sixth the cost of that of our grandfathers.

Four hundred carriage-axles once cost, for labor, $56.97, and now cost $8.20. Many more men are employed in the industry and the work is done ten times as fast and at one-seventh the cost for work. Similarly, 1000 watch-movements once cost $80,822, and now cost less than $1800; while the number of operations has been quadrupled and the time reduced to one-thirtieth. Five hundred yards of cloth, once costing $135, hand-made, now cost $6.81; 100 pairs of boots then cost $408, and now $35, hand-made and machine-made, respectively; time required is reduced, on the cloth, to one-half of one per cent. of its former value and, in the case of the boots, to ten per-cent. On 20,000 nails, $20 were once expended and now but 29 cents; while the time was then 150 times as great and the cost about 100 times as large as to-day. These are examples of the drift of the inquiry and its outcome.

It is thus evident that the use of labor-assisting machinery—less appropriately called 'labor-saving'—has permitted an enormous increase in the number of people employed in manufacturing, and, while increasing the number of operations in the making of each article, has reduced the time required to a fraction, often a minute fraction, of that formerly demanded, and has decreased the costs of product enormously. Meanwhile, it is known that the wages paid for labor in these directions have greatly increased and, with reduction of costs, their purchasing power has been, at the same time, immensely enlarged. Similar observations in France, reported by M. Levasseur, give precisely the same general results.

"*Abondance, puissance, économie: voila donc trois effets de l'emploi des machines qui sonts évidents,*" concludes M. Levasseur.

Mr. Wright's own summary of his work in this field adds the following deductions: "Machinery has established, or brought into activity, new principles in statute law; it has wrought many changes in common-law doctrine. It has increased opportunities to enjoy art and

*This principle was illustrated admirably in the case of copper-production, where rising wages and falling prices have continued for now many years. See SCIENCE, Dec. 4, 1896, page 817.—R. H. T.

literature, has lessened the frequency and the possibilities of famines, has increased longevity by making life safer and more comfortable. It has extended marvelously the power of production, and, consequently, of consumption. It has made the world cosmopolitan, upsetting old ideas and old customs. It has lifted struggling humanity to a higher plane and has stimulated a higher intelligence."

In agriculture our 45,000 workers are aided by the equivalent, in brain-power, crystallized in machinery, of over 300,000 men. Our 225,000 workers in cotton manufacture are aided by the equivalent of about three millions, by the multiplication of their productive power by use of their labor-assisting machinery. In flouring mills, 65,000 workers in the United States are made equal to nearly five millions. In paper-making, 30,000 men become equal to a million and a half. These workers of the United States, four and a half millions of men, with machinery at their finger-ends, turn out a product that it would require nearly forty millions of men to produce by hand. Locomotives, alone give us the equivalent of the working power, if unaided, of three hundred and fifty millions of men. Our own people derive about twice as great advantage from labor-assisting machinery as do European nations; the population of the United States being equal in productive power to 150,000,000 Europeans. Says Mr. Wright:

"The reflection comes that a labor-saving machine is best defined as a contrivance by which the dead still work. For the motive power of steam is the stored heat of the sun converted into present power. That heat gives force to the present era; while the intelligence of the inventors of motive power, or of the machines which control it, and their workmen are still working in unconscious iron and converting the heat into motion and doing the work of the world." Thus the machine "has practically enabled one generation of men to do the work of four or five generations."

The deduction of the editor of the *Scientific American* is that machinery, by raising wages, increasing their purchasing power, also thus lowering costs of all the necessaries of life, has become recognized "not, as the agitator will even yet suggest, the enemy of labor, but in every respect its best friend."

R. H. THURSTON.

Outlines of the Comparative Physiology and Morphology of Animals. By JOSEPH LE CONTE. New York, D. Appleton & Co. 1900. Pp., xviii + 492.

The impression given by the general appearance of this book is very favorable; print, illustrations, paper and binding are all good. A rapid turning over of the pages at first confirms this impression for the general plan of the work is most admirable. Function is the basis of the work and structure is described only so far as is necessary for the proper understanding of function. In short it continually reminds one of that admirable volume of a generation ago, the Principles of Zoology which was prepared by Agassiz and Gould and which served as the inspiration of many a youth.

In his treatment Professor Le Conte begins with some general accounts of life, cells and histology and then follows a general account of the organs and functions of animals, classifying them as the animal and the vegetative functions. In the treatment throughout man is made the type and the subject is treated in the descending scale.

A work built on these lines might be made almost ideal as a text-book for our schools, but not with our present knowledge. There are too many unknown quantities upon the physiological side. Professor Le Conte's book has also another shortcoming. It contains too many inaccurate statements. On the whole it is better upon the physiological side than where it attempts to deal with morphology, yet here it is far from free from error and ambiguity. Thus the account (p. 5) of the characteristics of plants is true only of the chlorophyl bearing forms; thus, again, the only suggested function of motor nerves is to cause muscular contraction; thus (p. 65) the electrical organs of a fish are stated to be organs for the conversion of nerve force into electricity just as a muscle is a structure for converting nerve force into mechanical power. On p. 58, along with an erroneous conception of the paths of sensory conduction, the ganglion cells of the dorsal roots are placed in

the posterior cornua of the cord. On p. 94 we find the statement that the fibers of olfactory and optic nerves are specialized for recognition of odors and light. Is not this rather a matter of nerve termination? In treating of the ear we find the statement that "in the vestibular sac and attached to the hair-like nerve terminals there are several little sand-like grains of carbonate of lime (otoliths)" and here and elsewhere the author seems to regard the sensory hairs as the terminations of nerves. On p. 218 it is stated that animals lower than hexapods are not known to make sounds intended to be heard. What shall be said of the stridulation of spiders and crabs? On p. 399 the aëration of the crustacean gill is in part attributed to ciliary action regardless of the fact that cilia are unknown in arthropods. The scaphognathite of the decapods is ignored. P. 342, the function of the echinid pedicellariæ is stated to be to convey food to the mouth. In the account of the evolution of the ruminant stomach (p. 317) the author is again at fault, for this complicated structure is not derived by simple division of a stomach like that of man, but by the incorporation of a part of the œsophagus into the organ. Again (p. 435), renal organs are stated to occur only in vertebrates, molluscs and arthropods. Where is the nephridial system of the worms, and have not the contractile vacuoles of the ciliates been shown to void sodium urate? P. 404, the respiration of the star-fish is said to be produced by drawing water into the perivisceral cavity through a multitude of pores but the branchiæ are ignored; while *Echinus* is stated to have tufted external gills around the mouth. The worst feature, physiologically, of the book is the recognition of a vital force.

On the morphological side the errors are far more numerous and we can only call attention to a few. Thus (p. 7) 'all animals must have a stomach"; how about tapeworms? P. 85, 'It is difficult, indeed impossible, to conceive how the vertebrate nervous system could have been evolved out of that of the articulates." Cannot exact homologies be shown between the two? Cannot we compare the distribution of white and gray matter and the origin of the ganglionated roots in both? On p. 91 a pedal ganglion is denied to the oyster. On p. 165 the optic ganglion is stated to act as a retina in the arthropod eye. On p. 172 the vertebrate lens is stated to be comparable to the invertebrate eye. Amphibians are stated (p. 184) to lack a middle ear; this is not true of Anura. On p. 186 the mosquito is credited with two pairs of antennæ. On p. 247 it is stated that we cannot trace homologies except within the primary branches —vertebrates, articulates, molluscs and radiates. What has become of Huxley's comparisons of ectoderm and entoderm of coelenterates and mammals, to say nothing about such homologies as can be drawn between nervous system, nephridia, cœlom and the like? Here and there we meet with statements regarding a radiate type of structure and a recognition of close affinities between coelenterates and echinoderms.

Again, the vertebral theory of the skull is maintained in several places, although it is stated that there is 'some doubt' if it be strictly true. Then there is no recognition of the fact that ribs are not homologous throughout the vertebrates. At various places it is stated that serial homology (metamerism) is mostly limited to the skeleton and the nervous system and is denied to the organs of vegetative life. There is no recognition of the fact that metamerism is mesodermal in origin; and none of metamerism in nephridia, blood vessels, gonads, etc. In the final section we meet this astounding statement (p. 481): "On the east coast of the United States we have two abrupt changes of coast fauna, one at Cape Cod and the other at Cape Hatteras. Scarcely a single species passes from north to south of these points, or *vice versa*."

The foregoing errors have been selected to emphasize the charge of inaccuracy, but a more serious fault is the lack of a broader grasp of the results of recent morphological and physiological research. This is not easy to illustrate, but is very apparent on reading the pages.

J. S. Kingsley.

Tufts College.

Books Received.

The Norwegian North Polar Expedition, 1893–1896 Scientific Results, Edited by Fridtjof Nansen. New York, London and Bombay. Longmans, Green & Co., 1900. Vol. I. Pp. viii+141, 44 plates. $15.00.

The Unknown. CAMILLE FLAMMARION. New York and London, Harper & Brothers, 1900. Pp. xii + 488. $2.00.

Brief Guide to the Commoner Butterflies of the Northern United States and Canada. SAMUEL HUBBARD SCUDDER. New York, Henry Holt & Co., 1899. Pp. xi+210.

Commercial Organic Analysis. ALFRED H. ALLEN. P. Blakiston's Son & Co., 1900. Vol. II., Part II. Pp. viii+330.

Inorganic Evolution as studied by Spectrum Analysis. New York and London, The Macmillan Co., 1900. Pp. x+191. $1.75.

SCIENTIFIC JOURNALS AND ARTICLES.

THE March number of the *Bulletin of the American Mathematical Society* contains the following articles: 'Mathematical instruction in France,' by Professor James Pierpont; a review, by Professor E. W. Brown, of Poincaré's Cinématique et Mécanismes, Potential et Mécanique des Fluides; 'Shorter Notices'; 'Notes'; and 'New Publications. The April number of the *Bulletin* contains a report of the February meeting of the Society, by the Secretary; 'Some theorems concerning linear differential equations of the second order,' by Professor Maxime Bôcher; 'Note on the enumeration of the roots of the hypergeometric series between zero and one,' by Dr. M. B. Porter; 'The summer meeting of the Deutsche Mathematiker-Vereinigung, at Munich, September, 1899,' by Professor James Pierpont; reviews of Hilbert's Grundlagen der Geometrie, by Dr. J. Sommer, and of König's Leçons de Cinématique, by Professor E. O. Lovett; 'Notes'; and 'New Publications.'

THE *Journal of the Boston Society of Medical Sciences* for March 20th, is largely devoted to abstracts of the papers read at the first meeting of the Society of American Bacteriologists, held at New Haven, Dec. 27–30, 1899. Several of these dealt with the question of purification of sewage and contamination of water supply. Charles S. Minot has a paper 'On the Solid Stage of the Large Intestine in the Chick, with a Note on the Ganglion Coli.' W. T. Councilman discusses 'The Lobule of the Lung and its Relation to the Lymphatics,' and Thomas Dwight notes a case of 'Absence of the Inferior Vena Cava below the Diaphragm.'

SOCIETIES AND ACADEMIES.

THE NATIONAL ACADEMY OF SCIENCES.

THE annual stated session of the National Academy of Sciences was held in Washington, April 17–19, 1900, with Dr. Wolcott Gibbs in the chair, and the following members in attendance: Messrs. Abbe, Agassiz, Allen, Barus, Beecher, Bell, Billings, Boss, Brewer, Brooks, Brush, Chandler (S. C.), Chittenden, Comstock (G. B.), Dall, Dana, Dutton, Elkin, Emmons, Farlow, Gibbs (W.), Gilbert, Gill, Hague, Hall, Hill (G.W.), Langley, Mitchell (S. W.), Morse, Powell, Putnam, Remsen, Rowland, Schott, Smith (E. F.), Walcott, Welch, White and Wilson.

The resignation of Dr. Wolcott Gibbs as President of the Academy was reluctantly accepted to take effect at the close of the session. His successor will be elected at the next April session.

Six additional members of the Council were chosen for the ensuing year, as follows: Messrs. J. S. Billings, H. P. Bowditch, G. J. Brush, Wolcott Gibbs, Arnold Hague, Simon Newcomb.

The following gentlemen were elected members of the Academy: James E. Keeler, Director of the Lick Observatory, Mt. Hamilton, Cal.; Henry F. Osborn, of Columbia University, New York City; Samuel L. Penfield, of Yale University, New Haven, Conn.; Franz Boas, of Columbia University, New York City.

The Academy adopted a report from the Trustees of the Barnard Medal recommending that the medal be awarded to Wilhelm Conrad Röntgen for his discovery of the X-rays. This medal is awarded at the close of every quinquennial period to such person as shall, within the five years next preceding, have made such discovery in physical or astronomical science, or made such novel application of science to purposes beneficial to the human race, as, in the judgment of the National Academy of Sciences of the United States, shall be esteemed most worthy of such honor.

Mr. Agassiz offered to give to the Academy

the sum of $5000 to be a part of a contribution to a building fund to erect a building for the use of the Washington Academy of Sciences and the local or affiliated societies, on condition that the land needed for such a building be given by the Government or obtained from other sources, and furthermore, that the sum of $100,000 at least be raised for that purpose, and that the National Academy of Sciences have such privileges granted as they may need.

Mr. Agassiz also offered to give $1000 towards a general fund for the National Academy of Sciences, provided that $20,000 be raised for that purpose. Mr. Theo. Gill offered to donate $500 to the general fund. These offers were accepted by the Academy, and committees will in due time be appointed to obtain subscriptions to these funds.

The following papers were read in the scientific session:

I. 'The Anatomy of *Nautilus pompilius*': L. E. Griffin. (Introduced by W. K. Brooks.)

II. 'West Indian Madreporarian Polyps': J. E. Duerden. (Introduced by W. K. Brooks.)

III. 'On the Use of Electric Motors, of the Shunt Type, for Solving Linear Differential Equations of any Order with Variable Coefficients': Reginald A. Fessenden. (Introduced by Cleveland Abbe.)

IV. 'On the Prediction of the Physical Properties of the Pure Metals': Reginald A. Fessenden. (Introduced by Cleveland Abbe.)

V. 'A Partial Explanation of some of the Principal Ocean Tides': Rollin A. Harris. (By permission of H. S. Pritchett. Introduced by Cleveland Abbe.)

VI. 'Secondary Enrichment of Sulphides in Ore Deposits': S. F. Emmons.

VII. 'The Cruise of the U. S. Fish Commission Steamer *Albatross* in South Seas, August, 1899, to March, 1900': A. Agassiz.

VIII. 'On the Zoogeographical Relationships of Africa': Theodore Gill.

IX. 'Report of the Watson Trustees on the Award of the Watson Medal to David Gill': Simon Newcomb.

X. 'A Human Bone from the Glacial Deposit at Trenton, N. J.': F. W. Putnam.

NEW YORK ACADEMY OF SCIENCES.
SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

A meeting of the Section was held on Monday evening, April 2nd. Professor William Hallock, of Columbia University, discussed the overtones of a tuning fork. The first regular overtone of a tuning fork is about two and a half octaves above the fundamental, but Lord Rayleigh pointed out that when the amplitude of the vibration became so great that the restoring force was no longer proportional to the displacement, the octave appeared, as indicated by theory. Lord Rayleigh recognized the presence of the octave with his ear, and by the use of a resonator. Professor Hallock obtained direct evidence of this effect by means of a photograph of a manometric flame, the capsule of which was resting against the prong of the fork.

In a paper on 'Specific Gravity Weighings,' Professor Hallock spoke of a number of points in which the ordinary operations can be improved. It is very convenient to use the principle of the Jolly balance, in which there is a pan always immersed, to hold the body when weighing it in water. The effect of capillarity on the supporting wire, which at best lessens the sensibility of the balance, can be avoided by sending a series of little waves across the surface of the water while weighing. To get rid of bubbles in little corners of irregular bodies, these bodies may be held under the tap at the sink and moistened with water before immersion, or still better, they may be moistened with alcohol and then with water before immersion.

Professor M. I. Pupin of Columbia University, described a new faradmeter which he had devised, an instrument for measuring the capacity of a condenser. This instrument is essentially a Wheatstone's bridge using alternating currents, in which one leg of the bridge consists of two resistances in series, and the other leg consists of two capacities in series, one of the two being that of a standard condenser, the other being the unknown capacity to be measured. In the bridge connecting the two points, one between the two resistances, the other between the two capacities, is a telephone. If the two separate circuits each containing one of the two capacities, are arranged so that the capacity reactance is by far the greatest part of the impedance in that circuit, then silence in the telephone will be obtained

when the two resistances are to each other inversely as the two corresponding capacities. The apparatus has been employed in the Columbia University laboratory and gave complete satisfaction. It is capable of a tolerably high degree of accuracy, but its principal merit is its convenience.

Professor J. K. Rees presented a paper by Miss C. E. Furness on a 'Catalogue of stars within one degree of the North Pole, and the optical distortion of the Helsingfors astrophotographic telescope.' The paper gave the results of measurements on 65 stars. By taking stars near the pole, the same group of stars can be taken at different angles with reference to the object glass of the telescope. At Helsingfors the pole is sufficiently far from the horizon to avoid trouble with refraction. From the measurements the distortion of the Helsingfors lens was found to be not appreciable.

WM. S. DAY,
Secretary.

TORREY BOTANICAL CLUB.

AT the meeting of the Club on February 28th the first subject on the scientific program was a 'Note on Apeiba,' by Dr. D. T. MacDougal, who showed specimens of leafy branches of this Tiliaceous tree, exhibiting flowers apparently seated on the leaves, an accidental but frequently quite stable position, due to abundant blossoms dropping from above, piercing the lower leaves and lodging there. Dr. MacDougal witnessed this peculiarity in trees cultivated in Jamaica, originally from British Guiana.

The principal paper of the evening was a discussion by Dr. N. L. Britton 'On the Flowering Plants collected by Mr. R. S. Williams in the Yukon Territory, 1898–1899.' Dr. Britton exhibited the plants collected, and by means of a sketch map of the region he compared the diverse floras of the Alaskan region. Mr. Williams' collection contains several new species and several others which are new to North America. The Ferns, Lycopodia, etc., of Mr. Williams' collection were reviewed by Dr. Underwood and Professor Lloyd. They include such widespread forms as *Cystopteris fragilis*, *Polypodium vulgare*, *Selaginella rupestris*, and species of *Equisetum* and of *Lycopodium*, including *L. annotinum*, and *L. Selago*. The Conifers include *Tsuga Mertensiana*. Dr. Britton is still engaged on a study of the similarly abundant Sedges, with several peculiar forms. *Carex vesicaria* is there cut for hay. *Eriophorum vaginatum* and *E. polystachyon* grow there also. The eight orchids were worked over by Dr. Rydberg.

The Birches are interesting, one of them new to North America. Another new birch has just been described from the Alaskan coast, but this is wholly different. Two *Polygonum* species occur, *P. viviparum*, and another peculiar to Alaska. *Rosa acicularis* occurs there, and one violet, *V. Macloskiei*. The Buffaloberry, *Shepherdia*, is there a shrub; *Cornus Canadensis*, *C. stolonifera*, *Empetrum nigrum*, etc., are present. Only three Umbelliferæ were collected. An important part of the flora is formed by the Heath family, about 20 species, *Dodecatheon* is there, *Primula Sibirica*, a *Gilia*, two species of *Polemonium*, a new *Mertensia*; only one Labiate; *Gentiana propinqua; Menyanthes trifoliata; Plantago aristata; Galium boreale; Linnæa borealis; Viburnum pauciflorum;* a new Valerian, etc. On the whole the flora is not so fully Arctic as we might have expected from the latitude.

Mr. R. S. Williams, the collector of these specimens, said there were few shrubs there except willows; for miles all is covered by spruce 15 to 20 feet high and not over two or three inches in diameter. A detailed discussion of the Forest-conditions of the Klondike will be furnished by Mr. Williams to an early number of the *Journal of the New York Botanical Garden.* Mr. G. N. Nash said there were 36 species of Grasses, 7 new, and some others new to North America, as *Calamagrostis Lapponica* and *Festuca altaica.* Professor Lloyd spoke of the interesting forms of *Lycopodium complanatum.* One in Montana and Idaho is irregular in habit, and has one spike on a peduncle. The Klondike specimens seem to be the Arctic condition of this Montana form and so agree with others from Labrador.

EDWARD S. BURGESS,
Secretary.

SCIENCE CLUB OF THE UNIVERSITY OF WISCONSIN.

THE March meeting of the Science Club of the University of Wisconsin was a memorial

session in honor of the late John Eugene Davies, a charter member of the Club and for more than thirty years a professor in physics in the University. From 1877 to 1890 Mr. Davies was in charge of the Wisconsin work of the United States Coast and Geodetic Survey. The base line of three miles which he measured, and upon which the triangulation system of the southern part of the State is based, has stood as a model of accuracy. Addresses were made by J. B. Parkinson, who gave a biographical sketch of Mr. Davies; by B. W. Snow, who spoke of physics in the University previous to 1891; by W. W. Daniells, who spoke of the sciences in the early days; by L. S. Smith, who discussed the work on the Coast and Geodetic Survey, and by A. S. Flint, whose subject was Dr. Davies' connection with the Washburn Observatory. At the close of the meeting the following resolution was unanimously adopted by a rising vote:

"In the death of Professor Davies the University has lost another of those teachers whose devoted services in the years following its reorganization were the foundation of its present prosperity. In the earlier years of his professorship he was obliged to teach many subjects and only to elementary classes. Yet in the distraction of these multifarious tasks, imposed by the necessities of a struggling institution, his love for the higher ranges of scholarship in his own department remained clear and strong. Throughout a professorship of more than thirty years he welcomed with eager interest every advance in mathematical physics and was in full appreciative sympathy with the development of that science, even in its remoter aspects. He loved his science for its own sake and was successful in imparting to his chosen students his own interest and pleasure in its pursuits. His kindly and serene personality endeared him to his associates, whether in the faculty or among the students. They desire by this minute to record their feelings of the loss in his death, both to themselves and to the University in whose service he spent his life."

A REGULAR meeting of the Club held March 22d, was devoted to a symposium on the microscope and its use in the various departments of science. The following program was presented: Construction of the compound microscope and its use in physics, B. W. Snow; its use in general biology, E. A. Birge; in cytology, R. A. Harper; in bacteriology, H. L. Russell; in chemistry, S. M. Babcock; in petrology, Wm. H. Hobbs; and in engineering, J. G. D. Mack. An exhibition of the different types of instrument and of accessory apparatus served to illustrate the subjects presented.

WILLIAM H. HOBBS.

CHEMICAL SOCIETY OF WASHINGTON.

THE 116th regular meeting was held Thursday, February 8, 1900.

The following program was presented:

J. K. Haywood—'The Adulteration of the Arsenical Insecticides.'

C. A. Crampton and F. D. Simmons—'Uncompounded Chemicals under the War Revenue Act' (with exhibition of specimens).

Wirt Tassin—'The Relation of the Chemical Society to the Municipality.'

F. K. Cameron—'The Genesis of Hardpan.'

The 117th regular meeting was held Thursday, March 8, 1900.

The program was devoted to a symposium on Iron and Steel, as follows:

Iron—The raw material; chemistry of iron-ore smelting, cast iron, properties of iron.

Steel—The raw materials, converting methods, the mill, castings, forgings and plates, special steels.

The participants were Messrs. Dewey and Tassin.

WILLIAM H. KRUG,
Secretary.

THE PHILOSOPHICAL SOCIETY OF WASHINGTON.

AT the 516th meeting of the Society held March 31st at the Cosmos Club, Mr. Marcus Baker read an obituary notice of Samuel Shellabarger. Mr. H. S. Davis, by invitation, described the present 'State of Progress on the New Reduction of Piazzi's Observations.' This paper appeared in the issue of SCIENCE for April 13th. Mr. Alexander Macfarlane's paper on 'Vector Differentiation' was summarized and presented by Mr. Radelfinger, and finally Mr. Wead discussed the discontinuity in functions arising from an infinite exponent, and the use of such discontinuous functions to limit the range of a given equation: *e. g.*, to the surface within a circle and outside a square; to the black squares of a checkerboard; to the surface of a parallelopipedon, etc. The title

of the paper was 'On certain Discontinuous and Indeterminate Functions.'

E. D. PRESTON.
Secretary.

DISCUSSION AND CORRESPONDENCE.

REQUEST FOR CO-OPERATION IN WORK ON THE COMING SOLAR ECLIPSE, ETC.

THERE is a very singular phenomenon observed during the moments immediately preceding and following total solar eclipses, that has, up to the present time never been satisfactorily explained so far as I know. Just before totality, usually about a minute before, alternate bright and dark bands are observed sweeping across the country. These have been called shadow bands by some observers, and diffraction bands by others. They can be observed to the best advantage by laying a large piece of white cloth on the ground.

In some eclipse reports they are styled 'Diffraction bands bordering the moon's shadow.' Fringes bordering a shadow should, however, move with the speed of the shadow. Observations show that the dark bands move quite slowly, from ten to twenty feet per second, while the shadow of the moon rushes across the country at cannon ball speed. Moreover, they move in one direction before the eclipse, and in the opposite direction after. The only half way plausible explanation that I have ever heard offered for the shadow bands is that they may be due to striæ in the atmosphere. This would bring them under the head of the scintillation phenomena treated of somewhat extensively in advanced works on optics, but I am unable to see how any such regular and symmetrical distribution of light and shade can result in this way. That the distance between the bands varies on different occasions lends some plausibility to this explanation, but it is not impossible that the width of the bands is a function of the location of the point of observation, that is to say of its distance from the center of the eclipse track. This can only be determined by numerous and extensive observations covering a wide tract of country, and it is to secure as many data as possible on this subject that I desire to secure the co-operation of all who are interested in the subject. Observations just outside of and just within the track of totality will be of especial interest. The observations can be made without any apparatus, and as the bands are not visible during totality, their observation will not inconvenience any who are more interested in the spectacular than in the scientific side. At the end of this article I shall outline as clearly as possible just how the observations should be made, and what data recorded. It has occurred to me that the stroboscopic disc may be of use in determining the cause of the bands. If a source of light produces in any way, moving bands of light and shade, it is obvious that if the eye be directed towards the source, it will receive more light from the source while a bright band sweeps across it, than during the transit of a dark band. If the alterations are not too rapid a fluctuation in the brilliancy of the source should be observed.

As a matter of fact, citing a special case, the bands are about three inches wide, and move with a velocity of about ten feet per second. This means that forty bands cross the eye every second, too many to cause any flickering effect. By means of a stroboscopic disc, which is merely a circle of cardboard with equidistant radial slits arranged to be rotated at varying speeds, it is possible to keep the eye in a dark or light band as long as we choose.

Suppose we are looking at the source of light through the slits of the revolving disc, and suppose that the speed of rotation is such that the slits cross the eye at the same rate that the dark and light bands do. This is practically keeping the eye continually in a dark or light band. If the rotation is a little faster or a little slower, the slits will alternately get into, and out of step with the bands, and the eye will be in a bright band one moment, and in a dark one the next. In this way we may make the speed of the fluctuations as slow as we please, and if we look at the sun's crescent through such a device we may possibly detect a flickering in whatever part of the source of light is operative in producing the bands. The disc should be about a foot in diameter with about eight slits in it, distributed uniformly. I should advise that three or four concentric rings of slits of different width be made, the eye being moved from one

to another. In this way the apparent brilliancy of the sun can be varied at will, which would increase the chances of detecting the flickering if it existed. The location of the flickering is to be carefully noted, that is, whether it is of a portion, or the whole of the crescent, or whether it is in the air close to the edge of the sun's limb. The disc can be rotated by hand by means of a whirling table, to be found in every physical laboratory. This simple arrangement will, I think, be found more satisfactory than a more complicated rotator, as the speed is more immediately under one's control.

I am planning to use such an arrangement myself, and hope that some of the other eclipse parties can arrange for the simple experiment also. The speed and width of the bands could also be determined by means of the stroboscope. If we receive the bands on a white cloth on which a scale is marked, and view them through the revolving disc, by carefully adjusting the speed of rotation, it is obvious that the bands can be made to appear stationary. Their width can then be accurately determined by counting the number in a given distance, and the speed with which they move calculated, if the speed of the disc at the moment is recorded. In this way any change in width could be measured.

While these observations can only be made by persons who have had some training in work of this nature, valuable data may be secured by any who are fortunate enough to live within the eclipse belt. I desire to secure, if possible, a complete record of the appearance of the bands over the entire country, together with statements regarding the direction of the wind, condition of the air, etc. The bands can be best observed by spreading a sheet or other large white cloth on the ground. As soon as the moving shadows appear, which will probably be about a minute before totality, lay a lath on the sheet parallel to the shadows, with as great accuracy as possible. Then try to estimate the width of the bands, and the velocity with which they are moving, also the direction in which they are going, that is whether from east to west or west to east. The width of the bands can be best determined, I imagine (I have never seen them), by estimating the width of a group, say five or six, or as wide a bunch as the eye can grasp and follow with certainty as to the number of dark bands in it. A scale for reference, preferably a white board with feet and half-feet marked with strong black lines, will be of assistance. It should be laid perpendicular to the shadows, that is at right angles to the lath. The speed can be estimated by trying to keep up with the moving shadows, and may be recorded as slow walk, fast walk, slow run, etc. Those who are accustomed to counting quarter seconds, can probably make a fair estimate of the speed by noting the time of transit of a band across the sheet. The shadows will disappear at the moment of totality, but will reappear again as soon as the sun's edge emerges from behind the moon. A second lath should be laid on the sheet, parallel to the bands unless their direction is the same, and the same observations repeated, noting whether the direction of motion is reversed. After the eclipse is over, determine the direction of the two laths as accurately as possible with the compass, and measure the angle between them. Note the direction of the wind before and after the eclipse, and record the general atmospheric conditions.

Tabulate the data as follows:

Before Totality.

1. Direction of the bands.
2. Width of bands. (Give all data, that is, number of dark bands in given width of the system.)
3. Estimated speed. State how estimated.
4. Direction of motion. Whether from east to west, or west to east.
5. General appearance. Whether sharp or hazy, whether contrast between light and shadow is considerable. If possible estimate relative intensity of illumination in dark and light areas.
6. Direction of wind. Temperature and general atmospheric conditions.

After Totality.

Repetition of the above.

Actual angle between the laths.

General remarks, and location of point of observation.

Reports should be sent to Professor R. W. Wood, Physical Laboratory of the University of Wisconsin, Madison, Wis.

R. W. Wood.

A STATEMENT REGARDING THE SITUATION AT THE UNIVERSITY OF CINCINNATI.

TO THE EDITOR OF SCIENCE:—Letters received by the writer from professional friends in various parts of the country indicate more than a passing interest in the university crisis at Cincinnati. The reason is not far to seek. The measure which has been here enacted shows that it is possible in the United States of America for nearly an entire college faculty to be summarily discharged without specific reason and without a hearing. This fact gives to a local trouble an aspect of national concern. The security of the tenure of office of every professor in the country is responsive to such a shock.

One is naturally inclined to shield from publicity a purely family trouble, but the common interest in the present case leads me to submit for the readers of SCIENCE a brief statement that may be of service to all who desire to find correct answers to several pertinent questions.

What is the explanation of this revolutionary procedure? Does the difficulty center in the Board of Directors, in the Faculty, or in the President? As one who has just resigned from the Faculty, after a term of service covering nearly seventeen years, I may seem in a measure disqualified to make an *ex parte* statement, but the demand is for facts rather than argumentation, and the main facts are best known to the Faculty.

A comprehensive view of the situation must embrace the Board, the Faculty and the President. I restrict my attention to the most salient features of these three phases of the main question.

The conditions as to each are somewhat exceptional. The Board of Directors consists, normally, of nineteen members, including, *ex officio*, the mayor of the city. They are nominated by the judges of the Superior Court. The term of office is six years. The members are generally men of considerable professional or business experience, but frequently without college training, or knowledge of university management.

The varied business of the Board is subdivided and referred to special committees, including a committee on finance, a committee on law, a committee on buildings, a committee on academic department, etc. While the final authority rests with the Board, the voice of each committee is practically decisive in its department. The members have seemed disposed to limit the expenditure of time and thought to the special duties assigned to them. The majority of them are seldom seen at the University even on great public occasions like commencement.

The educational horizon of members of the Board may be discerned from the following circumstance. The special committee in closest touch with the President met with a committee of citizens in order to confer concerning the present difficulty. The argument was advanced that the Board was acting strictly within its rights in the matter, inasmuch as it was simply a question of discharging and hiring employees. The changes contemplated were desirable, even from a business standpoint, since as good, or better men could be secured for less money.

During the twenty-five years which have elapsed since the organization of the university, the institution has been without a president.

The Dean of the Faculty has been charged with administrative functions and the deanship has been at times a rotary office. On several occasions a difference of judgment arose between the Faculty and members of the Board as to the internal administration. The Faculty took a positive stand, incurring thereby the displeasure of members of the Board. The depth and implacability of this feeling were never realized by the Faculty until the recent publication of a lengthy statement, drawn up by a special committee of the Board, in defense of their present course.

Again, the Faculty has received censure in not having been able always to act as one man in the government of the student body.

The reportorial mind has been quick to attribute any differences of opinion to personal ambitions and jealousies. I do not doubt the sincerity of members of the Board in asserting that many members of the Faculty strove to secure the deanship as a possible stepping-stone to the vacant presidency. This view is so far from the actual truth, however, as to be even grotesque. The deanship has long been a thank-

less and most undesirable office. One member of the Faculty who held the office for several years, accepted it reluctantly after much persuasion.

The several difficulties above referred to were never of such moment as to interefere seriously with the steady development of the institution; the number of students increased continuously, a high standard was always maintained, and the good will of the community was manifested by benefactions of increasing frequency and magnitude. Never were such evidences of public appreciation so marked, as in the year ending with June, 1899, at which time the new president was elected.

The Faculty had long desired the guidance of a wise president, and to President Ayers the members at once extended the assurance of their cordial co-operation and support. This attitude was not reciprocated.

From the published statement of the special committee of the Board, we infer that the president had been fully imbued with the ideas of members of the Board who were opposed to the Faculty. He had asked and received almost absolute power. How he has used this power is known. He was made the sole channel of communication between the Faculty and the Board, and he has made himself the judge as to what communications should reach the Board. In more than one instance he has withheld from the Board orderly communications addressed to it, and duly entrusted to him for transmission.

The summary dismissal of the Faculty, in the face of excellent work accomplished and recorded year after year, raised a storm of public indignation. A committee of prominent citizens, numbering over twenty-five was organized and a subcommittee was then appointed to make a thorough investigation and report. This committee was hard at work for several weeks.

It is in evidence that in October, soon after the opening of the term, the President gave a dinner at his house to the members of the Board, and that on this occasion he asked and received pledges of support in whatever he might recommend in the way of changes in the Faculty.

Whatever may have been the advice given to the President, he seems to have surpassed all expectations. Members of the Board have expressed surprise and dissatisfaction, but under the circumstances they felt under obligation to support the new administration.

In conclusion, I refer, for the benefit of all who desire detailed information, to the 'Final Report of the Citizens'-Committee on University Affairs' which will soon be issued in pamphlet form. A synopsis of the pamphlet is as follows:

1. Unauspicious opening of the college year.
2. Abrupt and sweeping demand for resignations.
3. Emphatic protest and peremptory resignation of Professor Myers in an open letter.
4. Public opinion finds expression in the organization of a citizens' committee which forms a subcommittee for investigation.
5. Report of subcommittee to the general committee of citizens. Much light thrown on the situation. The Faculty vindicated and President Ayers arraigned. The subcommittee instructed to appear in behalf of the Faculty at the next meeting of the Board.
6. Pleas for justice before the Board of Directors. A public hearing of the Faculty requested. A petition of the Faculty for an open investigation returned to the writers by reason of an alleged informality. Special committee of the Board appointed to draw up a reply to the citizens' committee and report at a special meeting. The minority denied representation.
7. The special committee of the Board makes an elaborate report. Indiscriminate accusations. General defense of the Board and of the President. The request of citizens refused. A hearing not granted.
8. Resignation of Professor French. The report accompanying the resignation not presented by the President, although addressed to the Board of Directors. The Board declines to hear the report when a demand therefor is made by one of its members.
9. Remarkable admissions by President Ayers.
10. The report of Professor French.
11. Review of the Board's defense.

Any one may obtain a copy of this pamphlet by addressing W. N. Hobart, 243 East Pearl street, Cincinnati, Ohio.

All official statements and reports, pertinent to both sides of the question, are given in full.

Thomas French, Jr.

Cincinnati, April 10, 1900.

INFORMATION WANTED.

The psychophysiology of anæsthesia is a productive subject greatly in need of adequate investigation and discussion. Both pure science and practical surgery have doubtless much to gain from a deeper-going study of experiences

under ether, chloroform, nitrous oxide, etc., than has as yet been made. Scientific literature has frequently contained accounts of isolated individual experiences reported most often because of their strangeness. A very large number of descriptions of the ordinary experiences is what is now desired, and to this end blanks have been prepared on which replies to certain simple questions may be written. All persons, and especially hospital surgeons, officers of medical societies, and instructors in medical schools, are respectfully requested to send to the undersigned for as many of these blanks as they care to distribute among persons who have been under an anæsthetic. These will be gratefully sent, and received when filled out.

GEORGE V. N. DEARBORN.
PHYSIOLOGICAL LABORATORY,
HARVARD MEDICAL SCHOOL,
Boston, Mass.

NOTE ON THE PIGMENTS OF THE COCCID CHIONASPIS FURFURA, FITCH.

I HAVE just had occasion to examine some specimens of *Chionaspis furfura* sent me by Professor C. A. Keffer, from Tennessee, and in so doing, I found some pigments which may be of interest to others than coccidologists. The female *C. furfura* is brown-pink, but on being placed in liquor potassæ immediately becomes olive-green. The addition of hydrochloric acid at once restores the brown-pink color, showing that the two are simply acid and alkaline phases of one pigment, the living female having an acid reaction. These two colors are strikingly like those seen in the feathers of certain birds, namely the jacana, and the herons of the subgenera *Hydranassa* and *Butorides;* the resemblance being so close as to suggest that the maroon and green colors of these birds are likewise due to two phases of a pigment closely similar to that of the *Chionaspis*. The eggs of *C. furfura*, abundantly present in the material examined, are purplish-pink, with orange portions due to an oil or fat. The oil retains the same brilliant orange color even after boiling in caustic potash, but collects in globules varying from 6 to 60 μ diameter. The purplish-pink pigment is turned Prussian-green by liquor potassæ, but in a short while this again alters to a clear indigo blue. The latter change is hastened by boiling. On adding hydrochloric acid, the blue becomes reddish-purple. The egg-pigment is therefore similar to that of the mother insect, yet apparently not identical.

T. D. A. COCKERELL.
MESILLA PARK, NEW MEXICO, March 31, 1900.

CURRENT NOTES ON PHYSIOGRAPHY.

PORTO RICO.

R. T. HILL has prepared some 'Notes on the Forest Conditions of Porto Rico' (U. S. Dep't Agric., Forestry Bull. 25), which are prefaced by a description of the island's configuration and by a plate taken from a relief model. The discontinuous axial sierra, steeper to south than north and mostly of volcanic rock, is of rugged aspect, less than 3500 feet in height. The mountains do not rise to a single crest line, but form a sea of conical peaks and beaded ridges, elaborately dissected by numerous ravines and valleys between knife-edged spurs of graded slope. Here habitations find no place in the narrow valley floors but occupy the mountain sides, where heavy rainfall and deep-weathered tenacious soil support a luxurious vegetation; coffee and tobacco are cultivated to the very summits. The sierra is surrounded by a narrow and broken 'collar' of limestone, forming coastal hills of heights up to 500 feet or more, round or dome-like in form, with few ravines; here the surface is sheeted with a thin red argillaceous residual soil. South of the sierra, where the climate is relatively dry, the hills are mostly covered with thorny vegetation or chapparal. Longitudinal valleys sometimes separate the hills from the sierra; transverse valleys divide the hills into groups separated by wide alluvial floors which open into triangular plains (filled estuaries) occupied by sugar plantations on nearing the coast. A great part of the island has been cleared of its original forest. The 3268 square miles of the island contain 26,650 farms, which therefore average 7.4 to the square mile; but much land once cultivated, is now 'ruinate' from long use without fertilizers or from soil-washing.

The 'Water Resources of Porto Rico' are described by H. M. Wilson (Water Supply and

Irrigation Papers, U. S. Geol. Surv., No. 32, 1899).

THE DUNES OF GASCONY.

THE great belt of dunes that borders the straight coast of Gascony is well described by R. Le Mang (Deutsch geogr. Blätter, Bremen, xxii, 1899, 235–256). The dunes frequently rise 40 meters (one reaches 89 m.) over a belt 6 or 8 kil. wide and 240 kil. long. Near the sea the ridges lie north and south, parallel to the shore; further inland they trend east and west, parallel to the prevailing winds. The inland dunes have long been forested and stationary; the shore dunes were until recently barren and wandering. Fields and forests were buried and villages were overwhelmed by the advancing sand; the mouths of streams were blocked and shifted; lagoons were pushed inland with rising water level, invading and drowning fields and villages. Now, after many years of experimental effort and nearly a century of systematic work, the advancing dunes have been arrested. A half artificial dune or dike runs along the beach, with very gentle slope to the sea; here the wear of winter storms must be repaired during the succeeding summer. Next follows a protection zone, 300 to 1500 met., wide, covered with stunted firs and bushes, where the first strength of the sea wind is expended. Then comes the great artificial forest of firs and oaks, under whose cover the invasion of the dunes has entirely ceased.

THE MORVAN.

AN area of crystalline rocks, forming an upland known as the Morvan, a northern branch of the central plateau of France, was visited in the spring of 1899 by a party under the direction of M. Vélain, professor of physical geography at the Sorbonne; and a report of the excursion is made by M. Martonne, instructor in geography in the university of Rennes (Annales de Géogr., viii, 1899, 405–426, maps and photos.). The mesozoic strata that once covered the crystallines of this district more or less completely are now worn back so that the ancient crystalline floor is broadly revealed as a plateau, gently undulating where it has longer been exposed to erosion, remarkably even where recently uncovered; the harder members of the overlapping strata have retreated in strong escarpments that rim around the crystalline area on the east, north and west, while the less resistant members are reduced to plains between the scarped reliefs. A recent general elevation is indicated by the narrow valleys, frequently having incised meanders, by which the uplands and lowlands are alike dissected. The origin of the drainage is not especially considered; it appears to be in greater part the accordant with the general dip of the strata away from the Morvan center, and hence would be classed as originally consequent.

THE FLÄMING.

BETWEEN the mountains of middle Germany—Harz, Erzgebirge, Riesengebirge—on the south, and the Baltic lowlands on the north runs a belt of low uplands, underlain by some inequality of rock-floor and built up as a 'diluvial plateau' by the moraine of an early glacial epoch; now cut into disconnected parts by the broad valleys of glacial rivers. The Fläming is one of these uplands, lying east of Magdeburg between the Elbe and the Spree. It is recently described by E. Schöne (Beitr. zur Geogr. mittl. Deutschland, herausg. von F. Ratzel. Wiss. Veröffentlichungen Verein f. Erdkunde, Leipzig, iv, 1899, 93–194). The softly rounded hills are separated by ramifying dry valleys or 'Rummeln' which lead streams in wet weather. Faint terraces on the sloping valley sides are ascribed to stream action during the erosion of the valleys, although in a photographic illustration they closely resemble pasture paths, and indeed their modification by sheep is noted in the text. The steeper valleys on the northern slope of the Fläming have supplied gravel for the construction of a number of flat alluvial fans on the floor of the bordering glacial-river trough.

W. M. DAVIS.

BOTANICAL NOTES.

FOSSIL PLANTS OF THE BLACK HILLS.

A RECENT paper in the nineteenth annual report of the United States Geological Survey, entitled 'The Cretaceous Formation of the Black Hills as indicated by the Fossil Plants,' by Lester F. Ward, is of more than usual in-

terest to the general botanist, since it is given over almost wholly to a discussion of the cretaceous flora of the region. Much space is given to the fossil cycads which have been found in abundance in several areas within the Black Hills. These are all referred to the genus *Cycadeoidea*, of Buckland, of which twenty-two species are described, twenty being new to science. The great majority of these were found in the Minnekahta region in the southern part of the Hills, the remainder occurring in the Blackhawk region on the eastern side. The fossil forests receive considerable attention also. These occur in the Minnekahta, Blackhawk, and Hay Creek regions, the latter on the northern side of the Black Hills. The systematic position of the trees here found as fossils, has not been determined, as the structure of the wood has been too much obscured in the process of silicification. One specimen of fossil wood turned out to be a new species of *Araucarioxylon*. Other fossil plants from the lower Cretaceous enumerated in this paper are, nineteen species of pteridophytes, twenty-six gymnosperms (in addition to those already mentioned), four dicotyledons, and six fruits of uncertain relationship. From the Dakota group there are, one pteridophyte and seven dicotyledons. One hundred and sixteen plates, several maps and a few wood cuts amply illustrate this interesting paper.

THE PHYSIOLOGICAL RÔLE OF MINERAL NUTRIENTS.

AN important paper (*Bulletin* 18) by Dr. Oscar Loew of the Division of Vegetable Physiology and Pathology is devoted to the discussion of the physiological rôle of the mineral nutrients of plants. After an introductory chapter the rôle of phosphoric acid, iron compounds, hydrogen compounds, alkali salts, and calcium and magnesium salts are taken up in succession. A full review will appear later, this note being intended merely to call the attention of biologists to a paper which must prove to be of great value to them.

THE FOREST RESERVES OF THE UNITED STATES.

HENRY GANNETT, geographer to the United States Geological Survey, publishes in the nineteenth annual report a collection of papers on the forests of the West, especially of the forest reserves created by executive order of President Cleveland about four years ago (Feb. 22, 1896). It is a thick royal octavo volume of 400 pages, illustrated with 110 plates, most of which are fine 'half tones' from photographs. A thick packet of maps, also, accompanies the volume. A study of the illustrations and maps, alone, tells the tale of wanton waste, which has been characteristic of our treatment of the forest covering of our country from the beginning. The lumberman who is only anxious to get out the best trees with the least expenditure of time and money, caring nothing for the future of the forest, and the careless 'camper' who leaves his fire for the winds to spread through the forest, together are devasting the western forests, as they have the eastern. No one can glance over this volume and not feel indignant over the heedlessness shown by the people who take possession of the forest lands of the Nation. Here and there nature is making an effort to reforest the denuded areas, showing us what we might do easily in the way of preserving these forest areas for our children. These reservations came none too soon, and yet we remember with what bitterness the President was assailed by greedy lumbermen, and a certain class of politicians always eager to curry local favor.

We may quote one paragraph from the paper by John B. Leiberg on the forest conditions of northern Idaho. "There can be no doubt as to what the future will bring. The complete destruction of the forest in this region as a commercial factor is beyond question, unless the forest is placed at once under effective supervision. At the present time less than 40 per cent. of the burnt areas are reforesting, and sections carrying the young growth are reburned annually. Sixty per cent. are either in the brush stage or would be entirely barren but for small quantities of coarse grasses or weeds. These tracts will nearly all reforest in time, but to accomplish this result fires must be kept down. The forest conditions prevailing in northern Idaho merely foreshadow future forest conditions elsewhere in the wooded districts in the west."

A STUDY OF FUNGUS POISONS.

By the use of a number of deleterious agents, Mr. J. F. Clark was able to determine approximately their toxic effect upon the germination and development of certain fungi. His results were published in the November and December numbers of the *Botanical Gazette*. He used five common moulds, viz: *Aspergillus flavus*, *Sterigmatocystis nigro*, *Oedocephalum albidum*, *Penicillium glaucum* and *Botrytis vulgaris*, on account of their ability to grow normally under the conditions imposed by the experiments. Twenty-eight chemical substances were used, including half a dozen acids, eight hydroxids, three oxidizing agents, five sulfates of the strongly toxic metals, etc. A table of results is compiled, giving the coefficients of injury, inhibition, and death point. The author's summary includes many points, three of which we may quote, viz: "(1) Fungi are in general much more resistant to most deleterious agents than the higher plants. In the case of the mineral acids a concentration of from two to four hundred times the strength fatal to the higher plants is required to inhibit the germination of mould spores under favorable conditions. (2) Different species of fungi present great differences of resistance to many agents. Of the agents tested in this study, $NiSO_4$ permitted the greatest specific variation and dichloracetic acid the least. (3) Particular forms of the same species present very different powers of resistance, depending probably on previous environment."

Charles E. Bessey.
The University of Nebraska.

THE LABORATORY OF THE U. S. FISH COMMISSION AT BEAUFORT, N. C.

The laboratory of the United States Fish Commission, at Beaufort, on the coast of North Carolina, will be reopened for work on the first of June, and will remain open until October. The laboratory is designed for research in marine biology (zoology, botany, physiology), and, for the present, is open to men only. The collecting outfit is particularly good, including steam launch, sailboat, skiffs, dredges, trawl, seines, surface nets, etc. The indoor equipment embraces the usual apparatus, glassware, and reagents, provided by marine laboratories. The more important works on the systematic zoology and natural history of the forms that are found on this part of the coast, will be on hand; and the current numbers of the more commonly used journals will also be received. Naturalists working at the station will find a collection of identified forms, illustrative of the fauna and flora of the region, together with a record of breeding times and local habitat of the species.

Beaufort is a pleasant village to which a few people come for a quiet vacation. The collections of the earlier naturalists, and the work of the Marine Laboratory of the Johns Hopkins University, stationed here under Professor Brooks for many years, made known the interesting character of the fauna—which is exceedingly varied and abundant, including most of the forms described for the South Atlantic coast. Research at the laboratory is untrammeled, it being assumed that every occupant of a table will, in the course of his investigations, add to our knowledge of the natural history of this part of the coast. Inquiries and applications for tables, for which there is no charge, should be addressed to the Commissioner of Fish and Fisheries, Hon. George M. Bowers, or to the director of the laboratory.

H. V. Wilson,
Director of the Laboratory.
University of North Carolina,
Chapel Hill, N. C.

PROFESSOR DEWAR ON SOLID HYDROGEN.

We are able to print in the present number of Science an interesting address by Professor Dewar before the Royal Institution on his work on the 'Liquefaction of Hydrogen.' Professor Dewar has continued his researches and gave a further lecture before the Royal Institution on February 6th, an account of which we take from the London *Times*.

The theatre of the Royal Institution was crowded to its utmost capacity to hear Professor Dewar lecture on 'Solid Hydrogen.' Sir Frederick Bramwell was in the chair, and among those present were Lord Lister, Lord Rayleigh, Sir F. Abel, Sir W. Crookes, Sir B. Baker, Sir Henry Mance, Professor Odling, Mr. T. W. Swan, the Solicitor-General for Scotland, Dr.

Ludwig Mond, Professor S. P. Thompson, Professor Hellmann, and Mr. Fletcher Moulton, M.P.

Professor Dewar began with some remarks about the nature of hydrogen, pointing out that many of the most advanced chemical thinkers had regarded it as being metallic in character, and that to Professor Odling belonged the credit, so far as he knew, of being the first to suggest the contrary, now recognized to be the fact. Proceeding to show a long series of experiments, he explained how it was a consequence of the physical properties of liquid hydrogen that not much could be done with it unless it was available in reasonable quantities. After proving that its temperature was some 70 degrees below that of liquid air, and explaining how reduction of temperature became disproportionately more difficult the lower the starting-point on the scale, he illustrated the difference in the behavior of liquid nitrogen and liquid oxygen when made to boil under diminished pressure. The temperature of both was reduced, but, while the nitrogen became viscid and ultimately solid, the oxygen absolutely refused to solidify. In fact, it was impossible to get solid oxygen in this way, the reason being that at the lowest temperatures it had an inappreciable pressure of vapor, whereas that of nitrogen was considerable. To give an idea of the power of liquid hydrogen as a cooling agent he performed an experiment depending on the same principle as Wollaston's cryophorus, with the difference that the fluid to be solidified was not water but liquid air containing a large proportion of nitrogen, while the material used to effect condensation was liquid hydrogen. He next showed how hydrogen could be liquefied in a closed tube, explaining the importance of this fact with regard to the determination of its density and other questions, and then exhibited the gas in the solid form. This result was effected by putting a portion of the liquid into a vacuum vessel isolated from heat as perfectly as possible. When the pressure in the vessel was slowly reduced, the hydrogen was suddenly seen to appear like a white mass of solidified foam, possessing the lowest steady temperature it was possible to obtain at present—viz, 258° below zero Centigrade, or 15° on the absolute scale. The fact that hydrogen did solidify in this way was in a sense a disappointment to any one who was anxious to reach very low temperatures, for a solid was a bad substance for cooling purposes. Coming to the uses of liquid hydrogen for scientific research, Professor Dewar first showed how it afforded the only means of obtaining solid oxygen. Another important application was to the separation of the more volatile gases of a mixture. The behavior of metals with regard to electrical conductivity at very low temperatures was a very interesting question. From experiments with liquid air it was expected that at the zero of absolute temperature pure metals would have no electrical resistance at all. But although the resistance curves appeared to be going straight to zero at the temperature of liquid air, he found that lower down, below the temperature of solid air, they bent sharply round, so that a finite resistance was indicated. In conclusion, Professor Dewar acknowledged the kindness of those who had contributed to the cost of these investigations, and paid a tribute to the skill and devotion of his assistants. Such researches were necessarily costly, but he could not share the view of those who suggested that the results would not be worth the cost.

X-RAYS AND PHOTOGRAPHIC PLATES.

A DISCOVERY of very great practical interest in X-ray work has been made by Professor Nipher at Washington University. He has discovered that when photographic plates are exposed to the light of an ordinary room for a few days, that they may still be used for taking X-ray pictures. If while the Crookes tube is acting on the plates they are still exposed to the ordinary light of a room, they develop as positives. The shadows are dark. If they are in a plate holder when exposed to the X-ray, the pictures are like those formed in the ordinary way, and they are apparently as clearly defined.

The advantage of the method is that the plates may be developed by the light of a lamp. The developer (hydrokinone) being weak and cool, the process may go on for an hour if desired, and all the details may be studied as

they appear. In this way, details which are sometimes obscured by over-development may be seen as they appear, although they might not show in the fixed negative.

The development of such plates in darkness is liable to fog the plates. If plates do fog, they may be cleared up by taking them nearer to the lamp.

The results will be published in a forthcoming number of the *Transactions* of the Academy of Science of St. Louis.

SCIENTIFIC NOTES AND NEWS.

THE usual spring meeting of the Council of the American Association for the Advancement of Science, was held at Washington on April 19th, with President Gilbert in the chair. Dr. Howard, the permanent secretary, read his report. The local secretary for the New York meeting reported that all the arrangements for the meeting were made, and that everything promised an unusually large and successful meeting. The number of important special societies meeting with the Association would be much larger than ever before. The sessions will be held at Columbia University except the address of President Gilbert, which will be given at the American Museum of Natural History. The Hotel Majestic, Central Park and 72d St., will be the headquarters of the Association.

PRESIDENT SETH LOW, of Columbia University, was elected president of the American Geographical Society, New York City, on April 17th, succeeding the late Charles P. Daly.

M. A. LANCASTER, director of the Meteorological Service of Belgium, has been elected a foreign member of the Royal Meteorological Society, of London.

MR. WM. G. FREEMAN, B.Sc., has accepted the position of technical assistant to the Imperial Department of Agriculture for the West Indies.

CAMBRIDGE UNIVERSITY will confer the degree of doctor of science on Mr. Charles Hose, of Saráwak, known for his contributions to the natural history of Borneo.

PROFESSOR FREDERICK STARR has returned from a three month's trip to Mexico.

THE Duke of Loubat has returned to New York from a trip in Mexico, where he visited the ruins of Mitla to view the explorations by Mr. Marshall H. Saville, of the American Museum of Natural History.

MR. ANDREW CARNEGIE has promised the trustees of the Carnegie Institute, Pittsburg, Pa., to become responsible for $3,000,000, the amount estimated as necessary for the proposed extension and enlargement of the building at the entrance of Schenley Park. The new building will be nearly six times as large as the present one. It will be 500 x 700 feet in size. The space now occupied by the museum will be transferred to the library, while the museum will be transferred to the new building.

M. ALPHONSE MILNE-EDWARDS, the distinguished French naturalist and director of the Museum of Natural History, died on April 21st, in his sixty-fifth year.

PROFESSOR WM. M. THRASHER, for forty years professor of mathematics at the Northwestern Christian University and Butler College, has died at Berkeley, Cal.

A CORRESPONDENT of the London *Times* writes: Captain Peter Astte Scott, R.N., who died on March 31st, at the age of 84, had had a long and varied career. He joined the Navy in 1829, served in the Antarctic expedition of 1839 under Sir James Ross, and only missed serving as lieutenant to his old friend Sir John Franklin in his last fatal Arctic expedition owing to his arrival in England too late. He had already served five years under that officer in Tasmania as naval architect and surveyor. From 1846 to 1866 (when he retired) he was employed on the marine survey of the Canadian Atlantic coast. From 1869 to 1889 he served in the marine department of Canada, the protection of the fisheries, as examiner for masters' and mates' certificates, and as general nautical adviser, and was well known to all who served on the North American station for his geniality and hospitality.

THE London *Times*, also, states that Mr. William Cross, the well-known naturalist and dealer in wild animals, has died at Liver-

pool, after an illness lasting several weeks. He was 57 years of age. As a collector of rare and curious animals Mr. Cross was without a rival, and probably no name was so well known in the remote regions where wild beasts are hunted and captured as his. His place of business in Earle street, not far from the Liverpool Exchange, was always full of strange and interesting beasts, and had a fame which probably no similar collection for purposes of trade has ever enjoyed. Here proprietors of zoological colletions and travelling menageries and all persons interested in animals and reptiles could count on finding objects worthy of attention, and here all importers of wild animals brought their wares. In addition to his chief establishment in Liverpool Mr. Cross had branches in Africa, America and China. He carefully studied all the living creatures brought under his notice, and was not only able to estimate their value from a commercial point of view, but also knew the best methods of treating them in captivity. Besides his large stock of animals Mr. Cross collected all sorts of curiosities, such as china, weapons, skins, and rare shells.

THE Arctic steamer *Windward* will sail from New York, in July, under American registry, by virtue of a bill recently signed by President McKinley. It will be under the command of Capt. S. W. Bartlett, of Newfoundland, who commanded the *Diana* and the *Hope*. The movements after joining Lieut. Peary, who is wintering in Etah, will be determined by him.

THE Minnesota Botanical Society was given preliminary organization at a meeting held in Minneapolis, April 14, 1900. Thirty-four members of the committee on organization were declared fellows of the Society, and a committee on constitution was appointed to report to the Fellows in June.

A CALL signed by Dr. Hexamer, President of the Farmers' Club of the American Institute; Dr. N. L. Britton, Director of the New York Botanical Garden, and James W. Withers, of *American Gardening*, has been issued for a meeting to be held in the museum building of the New York Botanical Garden, Bronx Park, for the purpose of organizing a 'New York Society of Horticulture.'

WE learn from *Nature* that the summer meeting of Cambridge University will be held on August 2–15th, and August 15–27th. Among the lectures to be delivered in the section on scientific progress are the following: *Physical Science:* The development of the nebular theory in the nineteenth century, by Sir Robert Ball, F.R.S.; The spectroscope in astronomy, by Mr. Arthur Berry; The wave-theory of light, by Sir George Stokes Bart, F.R.S.; Advances in the science of electricity, by Professor J. J. Thomson, F.R.S.; The conservation of energy, by Professor J. A. Ewing, F.R.S.; Chemistry and its applications, by Mr. M. M. Pattison Muir; Electro-chemical methods, by Mr. D. J. Carnegie. *Biological Science:* The theory of evolution and its influence on thought and research, under arrangement; Researches on the brain, by Dr. Alex. Hill. There will also be lectures on some aspects of advance in the following sciences: Geology, by Professor T. McK. Hughes, F.R.S.; Anthropology, by Professor A. Macalister, F.R.S.; Agriculture, by Professor W. Somerville; Bacteriology, by Professor Sims Woodhead. Mr. H. Yule Oldham will give a lecture on Geographical exploration in the nineteenth century; Professor W. M. Davis of Harvard University, will give six lectures On the study of the development of land forms. The study of special points in the following departments will be undertaken in sectional meetings: Chemistry and physics, under the direction of Mr. A. W. Clayden; Evolution, under the direction of Mr. F. W. Keeble, Mr. C. Warburton, and others; Anthropology, under the direction of Professor A. C. Haddon, F.R.S. There will in addition be arranged, primarily for teachers, practical courses in chemistry and geography.

THE National Educational Association's special committee charged with the inquiry into the proper seating, lighting, heating and ventilating of the school buildings, offers a prize of $200 for the best essay submitted on each of those topics, and of $100 for the second best essay. Each essay shall be limited to ten thousand words and shall be submitted in printed or

typewritten copy without signature, but with the name of the author enclosed with it in a sealed envelope and addressed to the chairman of the committee at Emporia, Kans. Three copies of each essay shall be submitted. They must be mailed not later than February 1, 1901.

THE Glasgow International Exhibition to be opened in May, 1901, includes eight classes, embracing agriculture, mining, industrial design and manufactures, machinery and labor-saving appliances in motion, locomotion and transport, marine engineering and shipbuilding, lighting and heating, science, education, music, sports and sporting appliances. Applications for space should be made to the General Manager, Mr. H. A. Hedley, not later than June 1st.

THE news regarding the plague is not reassuring. It continues unabated in India, the deaths numbering over 4000 a week. A total of 185 deaths is reported from Manila and 38 from Sidney. Deaths still occur in Mauritius, and cases are now reported at Aden on the Red Sea.

THE *Annales de l'Institut Pasteur* states that since the foundation of the Antirabic Institute at Algiers 1836 persons have been under treatment, of whom 645 belonged to the province of Algiers, 632 to that of Oran, 557 to Constantinople and two to Tunis. Out of this total, 1339 were French, Spaniards and Europeans of other nationalities, while 497 were Algerians. The number of deaths has been only nine, or rather less than one-half per cent.

THE Passmore Edwards Museum, in the Rumford-road, Stratford, is, according to *Nature*, now approaching completion and arrangements for the opening will shortly be made. The museum has been built and furnished by the Council of the County Borough of West Ham, at a cost of about 9000*l.*, of which 4000*l.* was the gift of Mr. Passmore Edwards. The main portion of the museum will be devoted to the Essex Museum of Natural History, belonging to the Essex Field Club, which is deposited in the building under agreement between the club and the Borough Council. The remainder of the building will be used as an educational museum in connection with the adjoining Municipal Technical Institute. The scientific control of the Essex Field Club collection remains with the club, and they contribute 50*l.* a year towards the curatorial expenses, the council contributing 100*l.* a year. The club appoints the curator. At their meeting on March 27th, the council resolved to set aside annually out of the Estate Duty Grant the sum of 1000*l.* for museum purposes. It is expected that from 500 to 600*l.* of this will be needed for the upkeep and maintenance charges, the balance being placed to the credit of a museum purchase fund, which will be treated as a capital fund, from which payments may be made from time to time for the purchase of objects and of the necessary cases, etc., in which to exhibit them. The Essex Field Club have appointed Mr. W. Cole as curator of their Natural History collections. The building itself, and the educational collections of the council, are under the charge of the principal of the Technical Institute, Mr. A. E. Briscoe.

MR. H. W. NEVINSON writes to the London *Daily Chronicle* from Ladysmith under siege, as follows: Again I was on Observation Hill two or three times in the day. It is impossible to keep away from it long. Whilst Puffing Billy was firing I tried to get sight of a small mocking bird, which has learned to imitate the warning whistle of the sentries. In the Gordons the Hindoo Purriboo-Singh, from Benares, stands on a huge heap of sacks under an umbrella all day and screams when he sees the big gun flash. But in the other camps, as I have mentioned, a sentry gives warning by blowing a whistle. The mocking bird now sounds that whistle at all times of the day, and what is even more perplexing, he is learning to imitate the scream and buzzle of the shell through the air. Another interesting event in natural history occurred a short time ago up the Port road. A Bulwan shell, missing the top of Convent Hill, lobbed over and burst at random with its usual din and circumstance. People rushed up to see what damage it had done, but they only found two little dead birds—one with a tiny hole in her breast, the other with an eye knocked out. Ninety-six pounds of iron, brass, and melinite, hurled four miles through the air, at unknown cost, just to deal a true lovers'

death to two sparrows, which are sold for one farthing.

THE New York *Evening Post* states that the exhibit of the division of forestry for the Paris Exposition is now complete and on the way to Paris. It will be one of the most novel of the government exhibits and will be wholly distinct from the commercial features of lumbering to be shown in another department. The display will be in the form of a hall or pagoda, the walls of which consist of large transparencies illustrating American forest conditions. These walls will be double and illuminated by interior electric lights. The pictures range in size from 3 by 5 feet to 4 by 6 feet. There will be two transparencies 6 by 10 feet, portraying groves of red fir and California big trees, two of the most impressive American trees. A point will be made of the relation of forestry to agriculture, and such subjects as protective forests, the use of trees in preserving water supply, the management of woodlands, etc., are fully illustrated. The extent of the timber resources of the United States will be shown by pictures from all important lumber regions. The distribution of forests will be shown by maps. Twenty of the most important American woods will be represented by sections of trees.

MR. WM. DUTCHER writes in the *Auk* that Commission houses in New York City, in their endeavor to obtain bird skins for millinery purposes, send out many circulars offering varying scales of prices for bird skins. Recently a postal card was sent by one of these firms to postmasters along the Gulf coast soliciting Gulls, Terns, Grebes, Barn Owls, etc. Dr. T. S. Palmer, of Washington, brought this matter to the attention of the Hon. Jas. Wilson, Secretary of Agriculture, who at once sent a very urgent letter to Hon. Chas. Emory Smith, Postmaster General, calling his attention to this direct violation of the law, and a letter has been sent to postmasters warning them against being parties to any transactions that violate the State laws.

THE automobile contests which will take place at Paris during the exposition period are exciting much interest. The speed contests will take place in July. In the contest between carriages there will be nine cash prizes, aggregating 30,000 francs. The first prize will be 8000 francs; the second prize, 6000 francs. In the contest between small carriages there will be seven prizes, aggregating 9000 francs, the first prize being 4000 francs. In the contest between motocycles there will be thirteen cash prizes, aggregating 8000 francs, the first prize being 2000 francs and the second prize 1500 francs. The contest between light-weight automobiles will take place in September. The program will include a contest of automobile cabs and delivery wagons capable of carrying loads of 1200 kilograms in weight. United States Commissioner General Peck has taken great interest in these automobile contests and will offer every facility for American visitors who desire to witness them.

ONE of the innovations in military transportation, says the *Electrical World*, which was brought about and developed largely through our war with Spain is the use of the automobile. The signal corps of the American army has recently been supplied with electric automobile wagons for use in the Philippines. These wagons are of two kinds, one to carry the instruments and material and the other to carry the personnel. The first is built like a covered ambulance, with rubber-tired wheels, and contains a storage battery capable of running the vehicle for thirty hours on one charge when carrying 1500 pounds of load. There are two 3½-H.-P. motors, one in each rear wheel. The maximum speed is about ten miles an hour. The other wagon is constructed like a high cart and is in other respects similar to the first. Both wagons are fitted with electric side lights, and the first also has electric lights in the interior. Other military applications of the automobile have been considered by the military world, but this is the first actual introduction.

AT a recent meeting of the Sanitary Institution, London, the annual report of the council was presented, stating that the question of additional premises for enlarging the museum and extending the work of the institute had received the careful consideration of the council, and although the leases of the present premises had

been renewed for another ten years these were scarcely adequate, and it had been decided to start a building fund, a proposal which was looked upon with favor by the president, the Duke of Cambridge. They had allotted £5,000 of the invested capital of the Institute as a nucleus of the fund and further donations had been received, but some £25,000 was expected to be required. Many lectures and demonstrations on sanitary science had been given to the students, who, during the period over which the lectures had extended, had had the free use of the library and museum, and the committee desired to tender hearty thanks to the lecturers. Two new examinations had been established during the year, one for inspectors of meat and other foods, and the other in practical hygiene for school teachers. There had been a steady increase in the number of students brought to the museum by lecturers and demonstrators, showing an appreciation of the teaching value of the museum. The total in 1899 was 2154, against 1958 in 1898 and 1674 in 1897. A comparison of the roll of the institute with that of the preceding year showed an increase in the number of members and associates, the total in 1899 being 2324, against 2130 in 1898.

UNIVERSITY AND EDUCATIONAL NEWS.

DR. D. K. PEARSON, of Chicago, on April 14th, which was his eightieth birthday, decided to add $525,000 to the $2,000,000 he has given to colleges. His principal gifts, to be paid before January 1, 1901, will be: Mount Holyoke College (Mass.), $150,000; Colorado College (Colorado Springs), $50,000; Berea College (Ky.), $50,000; Fairmount College (Kan.), $50,000; McKenzie College (Ill.), $25,000; Onarga College (Ill.), $20,000; Carleton College (Minn.), $50,000; Fargo College (N. D.), $50,000.

THE will of Mrs. Eliza Chrisman, who died in Topeka recently, has been filed in the Probate Court. She bequeaths the greater part of a fortune, estimated at $250,000, for the founding of the University of Topeka. The bequest is contingent on the Methodist churches of Kansas raising an equal amount within ten years. Mrs. Chrisman leaves $35,000 cash to the Ohio Wesleyan University.

MR. JOHN D. ROCKEFELLER some time since promised $100,000 to Denison University, at Granville, O., if the trustees should raise $150,000 this term. President Purinton has announced that nearly $125,000 had been secured.

THE establishment of a School of Commerce at the University of Wisconsin, Madison, was unanimously decided upon by the board of regents at their meeting on the 17th ult. Professor W. A. Scott is made director of the school, and a professor of commerce is to be appointed.

AT the Patrons' Day celebration of Colgate University on April 20th, the annual address was delivered by President Seth Low of Columbia University, New York, who took as his subject, 'The College and the University.'

IT is now said that Dr. E. Benjamin Andrews will probably accept the chancellorship of the University of Nebraska.

EIGHTEEN fellowships have been awarded at Columbia University, of which the following are in the sciences, falling more immediately within the scope of this JOURNAL:

Hartley Burr Alexander, Philadelphia, Pa., Philosophy, University of Nebraska, A.B., 1897.

Robert Henry Bradford, Salt Lake City, Utah, Metallurgy, University of Utah, B S., 1895.

William Austin Cannon, Palo Alto, Cal., Botany, Stanford University, A.B., 1899.

Robert Heywood Fernald, Cleveland, O., Mechanical Engineering, University of Maine, B.M.E., 1892.

George Irving Finlay, New York, Geology, Harvard University, A.B., 1898.

Thomas Jesse Jones, Greenfield, O., Sociology, Marietta College, A.B., 1897; Columbia University, A.M., 1899.

Austin Flint Rogers, Lawrence, Kan., Mineralogy, Kansas State University, A.B., 1899.

Harry Beal Torrey, Berkeley, Cal., Zoology, University of California, B.S., 1895, and M.S., 1898.

Clark Wissler, Columbus, O., Psychology, Indiana University, A.B., 1897; A.M., 1899.

DR. A. OSANN, docent in geology in the University at Bâsle, and Dr. M. Smoluchowski von Smolan, docent in theoretical physics in the University at Lemberg, have been promoted to assistant professorships. Dr. Fünfstück, docent in botany in the Polytechnic Institute at Stuttgart has been made full professor. Dr. Ed. Buchner, professor at the Agricultural Station of Berlin, has qualified as docent in the University.